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FOUR BEACONS, totaling 2-billion candle power, atop the Empire State Building as seen when looking south from the RCA Building, provide the world's brightest continuous source of man-made light. Story on page 431.

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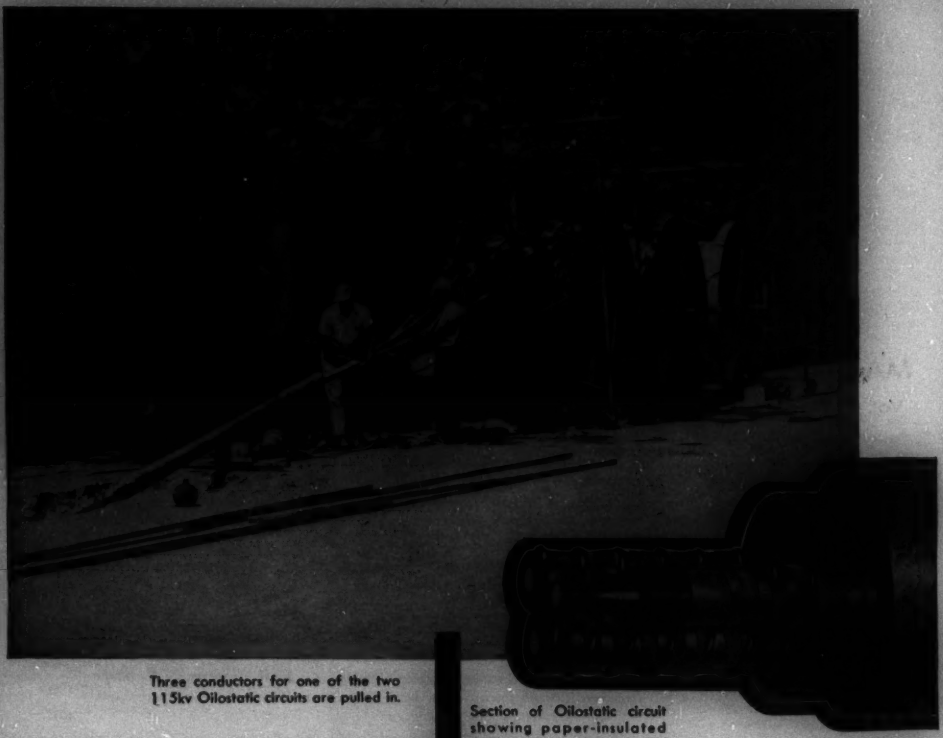

Three conductors for one of the two 115kv Oilostatic circuits are pulled in.

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AIEE and Its Structure

M. D. HOOVEN
PRESIDENT AIEE

The actual structural breakdown of the Institute is delineated, using the Committee on Air Transportation as a working example.

DALLAS is a delightful place. A District Meeting luncheon which puts your Board of Directors on display provides a distinguished point of departure for a quick trip across the whole field of engineering as seen from an Institute viewpoint. If, in line with the theme of the Dallas meeting, the Institute is imagined to be an airplane, it can be flown across this engineering field, thus providing an opportunity to describe in detail the structure from which the survey is being made as well as the area over which it is being flown. If there be those who say that this analogy puts the Institute up in the air, let them say it!

The American Institute of Electrical Engineers (AIEE) is the largest engineering society in the world. As of March 1, 1956, it had 49,793 members. It has 11 geographical districts, not the least of which is the South West District. It has 109 Sections, 139 Student Branches, and 9 Affiliate Student Branches. Each section and each student branch, is a part of a district. Each district is headed by a vice-president, who is a member of the Board of Directors.

An additional geographic entity is about to be added. Requests have been received by the Board for recognition of groups of AIEE members who are distributed throughout the free world. Individuals in Ireland, Formosa, and in many countries have suggested that AIEE owes its overseas members something more than its publications. Thus, at the Winter General Meeting in February 1956 the Board approved, in principle, the establishment of Overseas Chapters, even though the American Institute of Electrical Engineers does not plan to be anything more than its name implies. Sections will be confined, as at present, to Canada, Mexico, and the United States and its possessions. The number of sections increases annually, mostly by partition of existing areas. New student branches are usually installed immediately after accrediting; new affiliate student branches are installed in nonaccredited colleges as they apply.

So much for the geographical portion of the organization. There are, of course, a large number of general committees, in which geography plays no part; 25 of these are listed in the yearbook.

Most closely associated, however, with the first objective of the Institute as stated in the Constitution—the advancement of the theory and practice of electrical engineering—are the Technical Committees, of which there are 41 with well over 200 subcommittees. Annually they present 1,459 technical papers at 342 sessions at 7 Institute meetings and 19 special technical conferences, some of which are presented in conjunction with other engineering societies. The Technical Committees are divided into five divisions. Next year there will be 6 divisions, 50 Technical Committees, and 250 subcommittees, inasmuch as the Board has approved the formation of a new division, the Instruments and Measurements Division. The number of Technical Committees increases annually, sometimes by partition, sometimes by opening a new field.

One good way to describe the place in the sun of the Technical Committee would be to describe in detail a typical one. The Committee on Air Transportation is a good subject. The main committee and its half-dozen subcommittees include 100 members active in the general administration of this subject and an unestimated number active in local areas and sections. There have not, as yet, been developed any formal channels of communication between general and local groups, but cross-fertilization of ideas occurs through the wide geographical dispersion of membership. Local groups meet as often as monthly, as is the case with a very hard-working group in Baltimore, which has a membership as large as that of the national committee itself. There is no need to speak of the high interest shown in District 7.

The Committee on Air Transportation, its associated committees on Land and Marine Transportation, the Committee on Domestic and Commercial Applications, and the Committee on Production and Application of Light form the General Applications Division.

The General Applications Division and the four other technical divisions form the nucleus of the Committee on Technical Operations. The Communications Division covers telephone, telegraph, and radio. The Industry Division covers electrical engineering in the great manufacturing industries and primary industries such as chemical, mining, and metallurgy. The Power Division, in general, covers the electric utility field. The Science and Electronics Division, in a sense, filters into all divisions, as its name implies, carrying particular responsibility for specific development and design, setting up joint committees with other divisions where the situation requires it. The new Division, that on Instruments and Measurements, has been in existence as a committee far back in Institute history, and until its recent formation as a division worked as part of the Science and Electronics Division.

The technical paper output of the General Applications Division and of the Industries Division is combined in one

Full text of an address presented during a luncheon at the AIEE South West District Meeting, Dallas, Tex., April 2-4, 1956.

M. D. Hooven is electrical engineer with the Public Service Electric and Gas Company, Newark, N. J.

bimonthly publication, as is that of the Communication and Science and Electronics Divisions. The Power Division produces a third bimonthly. Articles from the combined fields are chosen for the monthly magazine, *Electrical Engineering*, on the basis of general, rather than specific, interest.

Thus, the entire field of electrical engineering is covered and covered well. This does not mean that there may not be hiatuses or overlaps; the operating structure, however, was designed for flexibility and fluidity. The Board of Directors feels that it has achieved a structure which encourages investigation into every field of electrical engineering.

The Committee on Technical Operations supervises the technical affairs of the Institute. In addition to the division chairman, it includes in its membership the chairmen of the committees on Standards, Education, Research, Management, Safety, Prize Awards, and Publication. There are common duties among all these general committees and all of the technical committees. The Standards Committee, as an example, may work with each one of the technical committees in development of Institute standards.

The administration of the Institute's local affairs falls under the Sections and the Student Branches, in turn co-ordinated by the Sections Committee, the Student Branches Committee, and the District Vice-President. Section chairmen, like committee chairmen, have the privilege of appearing before the Board of Directors. Section chairmen also form the District executive committee under the chairmanship of the vice-president who sits on the Board. Other general committees also find their duties in the administrative rather than in the operations side of the Institute. These include Constitution and Bylaws, Public Relations, and various honors and medals committees. The Board of Examiners, with a membership consisting entirely of Fellows of the Institute, is the watchdog on admission. Planning and Co-ordination, among other duties, makes detailed organization studies for the Board of Directors. Numerous other excellent and capable committees carry Board burdens. That is how electrical engineers operate and administer internal affairs.

What, however, is the Institute doing in the field of engineering as a whole? The Board of Directors has about as many responsibilities externally as internally. Although AIEE is the largest of all the subdivisions of the profession, only one quarter of all engineers can be designated as electrical engineers. This means, of course, that there is a continual requirement on AIEE to work in the field of engineering as a whole. The Board of Directors has many representatives co-operating with other engineering bodies, either formally or informally.

The oldest "umbrella" group of societies is the United Engineering Trustees (UET), Inc., formed as the United Engineering Society in 1904 for "the advancement of the engineering arts and sciences in all their branches and to maintain a free public engineering library." Besides the electricals, it includes the civils, miners, and mechanicals. This group is usually referred to as the "Founder Societies." UET operates the Engineering Foundation, the Engineering Societies Library, and the Engineering Societies Building, presented by Andrew Carnegie. In addition, UET acts as treasurer for Engineers Council for Professional Development (ECPD), and custodian and administrator of a number of Funds of interest to broad segments of the engineering profession.

ECPD consists of the five founder societies plus the American Society for Engineering Education, the National Council of State Board Engineering Examiners, and the Engineering Institute of Canada. Founded 24 years ago for the purpose of maintaining high standards within the engineering profession, it has long been an excellent example of what can be done by co-operation of many bodies. Its work on accrediting of engineering curricula, codes and ethics, high school guidance, recognition, and similar subjects, is participated in with willingness and drive by all engineering societies, regardless of formal connection. It operates as a loose federation with its working personnel being supplied by all societies, members or not.

Engineers Joint Council (EJC) is the newest umbrella type of organization. Founded 15 years ago as a conference of founder society presidents, it established an Exploratory Committee for unity of the profession and within the past few years has expanded in a federation type of organization to the impressive size of 9 constituent, 2 associate, and 2 affiliate bodies, with more being added constantly, all of them together representing about 200,000 engineers. The delineation between its activities and those of ECPD has been described by Dr. Harry Rogers as extra-professional for EJC and intra-professional for ECPD. EJC has done outstanding work on the shortage of engineers (Engineering Manpower Commission), water problems (National Water Policy Panel), and similar subjects of great importance to the entire profession. EJC and ECPD are working jointly on a very ambitious project—stocktaking of the profession and examination of how it fits into the demands of our present culture.

American Society for Engineering Education (ASEE) is another type of across-the-professions organization. Its individual members are recruited from all the major disciplines. It was founded in 1893. AIEE members have traditionally sparked its activities (the famous Wickenden Report, the Jackson Report, etc.) and provide a good portion of its present members. It is well represented on the Board of Directors. ASEE is a constituent body of both ECPD and EJC.

National Society of Professional Engineers (NSPE) is the same kind of across-the-profession individual member society as ASEE, although with a different purpose, of course. It was founded in 1934. Many electricals belong, although not in the same ratio as their numbers in the profession as a whole (civils, 41 per cent; mechanicals, 26 per cent; electricals, 18 per cent; and others, 15 per cent). NSPE puts its first emphasis on licensing; although AIEE supports registration, it does not make it a prerequisite for membership. NSPE's geographical setup makes it ideal for local representation, and it has made use of it wholeheartedly in supporting ECPD's high school guidance work. It does not belong to EJC, although it has participated in many of its activities. There are other regional

across-the-board individual membership societies and at least one other important national (American Association of Engineers with over 5,000 members) but none approaching NSPE's 30,000 members. NSPE is also well represented on AIEE's Board of Directors.

Institute of Radio Engineers (IRE), founded in 1914, is the most heavily cross-represented of any of the engineering societies in AIEE. At least one out of every eight persons in either institute is a member of the other. IRE, because of a long-standing tradition that its sole interest is technical, does not belong to any of the umbrella bodies. Because IRE represents the identical segment of the profession, its closest relationships, therefore, are with AIEE, there being more than 100 joint student branches, in the universities, and innumerable joint meetings at the technical committee and section levels. IRE has experienced a tremendously rapid growth since the end of World War II.

Illuminating Engineering Society (IES) is another technical society with heavy cross ties with AIEE. Cross representation on committees is usual. The same applies to the engineering sections of Edison Electric Institute, National Electrical Manufacturers Association, American Railway Association, Radio-Electronics-Television Manufacturers Association, and many other electrical groups in the engineering field.

CONCLUSION

THE ENGINEERING FIELD is an immense one. The interrelationships are complex and varied. There are those in the Institute who think progress is too slow on one front, too rapid for comfort in others. It is difficult for one member, who has had a single set of experiences, with one situation in one locality, to see why his fortunate (or perhaps unfortunate) experience cannot be transmitted immediately into general action. The Board of Directors asks patience. Secure in its knowledge that the membership desires to be a part of a single profession, the Board will go more than half way in meeting any constructive effort on the part of any other engineering group. The Board feels that a unity of approach to many problems of the profession has already been achieved; that unity of organization of the entire engineering profession awaits only the full expression of opinion on this subject by all engineers in all societies. AIEE opinion has been surveyed and resurveyed for many years with but one result—the expression by all of a positive desire to unify the profession.

First Microwave Telephone System Installed

Microwave transmission, solution to an ever growing number of communications problems, bows in a new role for General Telephone Company of Marion, Ohio. A Bryan-to-Fort Wayne microwave system has been activated as a joint project between General Telephone Company of Ohio and The Home Telephone and Telegraph Company, Fort Wayne, Indiana.

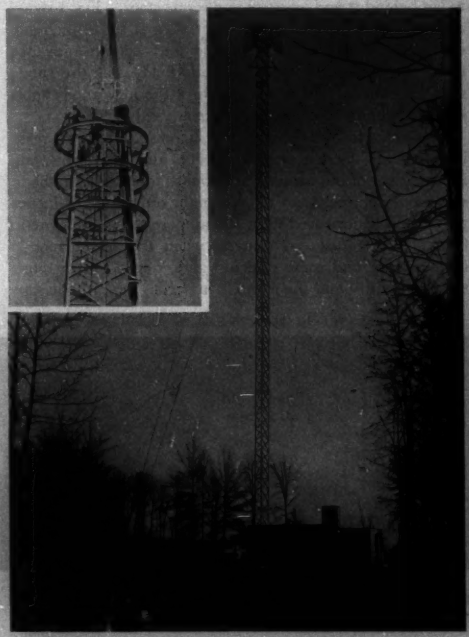
While not the first microwave system used in telephony, the FCC-sanctioned move of General Telephone is the first microwave system used by a telephone company exclusively for the transmission of telephone messages in the state of Ohio; and is one of the first systems beamed across a state line to connect telephone exchanges.

Although the FCC has issued call letters for the radio network, subscribers can place or receive calls on the system to or from any place in the world without being aware of the microwave connection and no maintenance engineer will be required on duty at any of the various exchanges.

The system was arranged initially for a capacity of 48 channels with a possible expansion to 72. Information now available permits expansion of the system to 240.

The picture shows the 170 foot microwave terminal and repeater radio tower with associated antennae. The two 10-foot reflectors at top of tower are (left) facing Bryan, Ohio, and (right) Fort Wayne, Indiana. The building at the foot of the tower, houses the carrier and radio equipment used with General's new microwave system.

Pictured in inset is a 10-foot parabola being lowered into place atop the 200-foot microwave tower.



Properties of a D-C Arc in a Magnetic Field

L. P. WINSOR
MEMBER AIEE

T. H. LEE
MEMBER AIEE

THE BEHAVIOR of direct-current arcs when subjected to uniform transverse magnetic fields up to 200 gausses has been investigated at atmospheric pressure over a current range between 3 and 100 amperes. Electrodes studied include silver, copper, aluminum, carbon, tungsten, molybdenum, nickel, and titanium.

The magnetic field was produced by a solenoid 3 feet in length by 12 inches in diameter, with the electrodes and contact-making mechanism mounted on a textolite disk which was fitted snugly inside the solenoid. Parallel 1/4-by 1/4-inch square bar electrodes were mounted horizontally with the upper electrode the cathode. A movable contact, connected electrically to the anode, made initial contact with the upper electrode and established the current.

Two distinct modes of arc travel are observed. The first, which occurs in the lower current range is distinguished by a cathode spot which moves continuously at a uniform velocity. The cathode spot leaves a continuous track, showing very little burning on the surface of the electrode. At the smallest currents the anode spot, as well as the cathode spot, moves continuously, and the entire arc progresses along the gap at uniform velocity. When the arc current is increased to higher values, the anode spot no longer follows the uniform motion of the column, but tends to lag behind it and advance in discrete steps. Fig. 1 shows a typical arc between copper electrodes at a half-inch gap spacing. Note how the cathode and column advance under the influence of the magnetic field while the anode spot tends to lag. The formation of the new anode spots and extinction of the old ones are clearly exhibited.

The arc velocity is observed to increase with an increase in either arc current or flux density, and to be relatively independent of the cathode material so long as the cathode spot advances freely. A velocity of the order of 1,100 inches per second is measured for a 100-ampere arc in a magnetic field of 150 gausses. However, when the arc current is increased beyond some critical value, dependent on both the flux density and the cathode material, the cathode spot ceases to advance with uniform motion and tends to become fixed to one spot, while the column is forced ahead. When the column stretches out far enough, it may come in proximity with the negative electrode and help establish a new cathode spot. Both the cathode and anode spots jump ahead in a random manner, apparently independent of each other, so that either spot may lead or lag the other. The velocity is reduced to a fraction of the velocity observed in the first mode and the results are not reproducible.

The two different modes of arc travel were observed for most of the electrode materials studied. For copper, the transition was first observed at a current of 109 amperes and a flux density of 25.8 gausses. The arc velocity was reduced to only 130 inches per second compared with about 300 inches per second that would have been obtained if the first mode velocity were extrapolated. A decrease in arc current to 49 amperes caused the arc to travel in the first mode again with the velocity increased to 200 inches per second. At 109 amperes, an increase in flux density to 62 gausses also caused the arc to revert to the first mode, increasing the arc velocity to 650 inches per second. With silver electrodes, the first mode was observed at 100 gausses for a current of 55.5 amperes, while the second mode occurred for the same current at 68.8 gausses. For the other materials tested, the transition current was relatively low.

It was also observed that when the cathode is clean, there is no motion of the cathode spot. In addition, if the arc is drawn first and then the magnetic field is energized, the cathode spot tends to stick. However, when the new spot is formed, its continuous motion will then start if the current, the magnetic field, and the cathode surface condition permit such a continuous motion.

A study of the tracks left on the anode of the arc provided an excellent opportunity to estimate the current density of the anode spot. The technique employed was similar to that used by J. D. Cobine and C. J. Gallagher to measure the cathode current density. Current densities in the range between 10,000 and 110,000 amperes per square centimeter were measured. These values are in remarkable agreement with the approximation of 10,000 to 50,000 amperes per square centimeter estimated by J. D. Cobine and E. E. Burger. The higher current densities were found to be associated with the refractory materials.

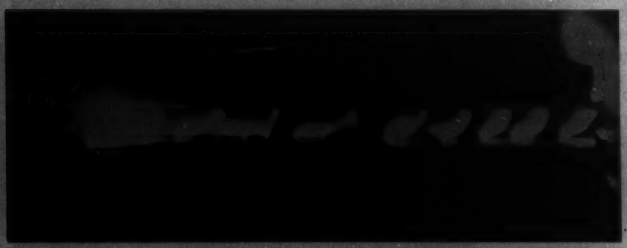


Fig. 1. Photograph of a copper arc. Current 71 amperes, flux density 26 gausses. Cathode at top, anode at bottom.

Digest of paper 56-132, recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956. Scheduled for publication in AIEE *Communication and Electronics*, 1956.

L. P. Winsor is with Rensselaer Polytechnic Institute, Troy, N. Y., and T. H. Lee is with General Electric Company, Schenectady, N. Y.

A World Look at Usefulness of Nuclear Power

W. L. CISLER
FELLOW AIEE

There is a universal, basic drive toward better living through expanded utilization of energy. The progress and promise of nuclear energy uses in the electric power field are discussed.

BECAUSE of the very great interest in atomic energy, it is quite natural that we should give thoughtful consideration to its ultimate usefulness. This discussion is limited to the electric power aspects of the situation, but nuclear energy undoubtedly will be utilized for many other important purposes.

The principal reason for the tremendous world-wide interest in atomic energy is, I believe, that the world is becoming more and more energy conscious. Men everywhere are realizing that the whole history of civilization shows a close relationship between the utilization of energy and the progress of the human race. Everywhere, energy is being identified with better living, less drudgery. Electrical energy in particular has become a universal symbol of progress toward a better and more abundant way of life. It has become a language of progress and betterment.

ENERGY AND PROGRESS

MEN IN THE WORLD OF TODAY think of human progress and the utilization of energy as going hand in hand. This is perhaps the main reason why the minds of men everywhere are busy seeking out and piecing together bits and fragments of new knowledge concerning the atom. This urge to delve into the atom's secrets, so well attested at the International Conference on the Peaceful Uses of Atomic Energy at Geneva last August, is more than just scientific; it is more than merely nationalistic. It appears rather to be a universal drive toward the better living promised by a vast new energy source—power derived from the heat of the fissioning atomic fuels, uranium and thorium—and in the more remote future the possible fusion of the atom as a source of heat.

Herein lies a challenge—to achieve performance from these new fuels. The immediate question is: What is the nature of atomic energy? Perhaps as in the case of electricity, nobody really knows. But we have learned a great deal about how atomic energy behaves.

Practically, and in particular connection with the generation of electric power, it is simply the same thermal energy with which we are already familiar, but derived from a different kind of fuel, and by a different process. Chemical reactions of oxygen and carbon are replaced by the nuclear action of fission.

The big difference between our present fossil fuels and nuclear fuels is the tremendous heat potential in relatively small amounts of nuclear fuel.

WORLD SIGNIFICANCE

WE HAVE AVAILABLE in atomic power, therefore, a promising answer to the universal drive toward better living through expanded utilization of energy.

The industrial countries see an indefinite postponement of the depletion of their conventional sources of energy. The underdeveloped countries associate their ambitions for a new and more equal place in the world with an abundance of electric power.

It is worth reviewing quickly some of the energy needs of the world. Experts in the measurement of the world's energy resources said, at Geneva, that we will need to double the world output of electric and other forms of power by 1975 and more than double it again by the year 2000. This is more than conventional fuels can provide without increasing costs to extremely high levels. In Europe, coal production already lags behind the needs and even though oil supplies have increased, they are often remote. In the foreseeable future, we will no doubt need all that can be found and transported for uses to which oil is peculiarly suited in chemicals, transportation, and the like. Increased efficiency in the use of coal and oil can help defer the inexorable cost increases, but in 20 to 50 years we can expect even these savings to dwindle.

The doubling of requirements every 20 years or so presents a startling demand. Two British representatives at Geneva estimated that the reserves of solid fuels, liquid fuels, and natural gases by the year 2025 would be reduced to 300 years' supply at the then prevailing rate of use, and if the rate of requirements continues upward, supplies would be used up even more quickly.

For the first time people of the underdeveloped areas see the possibility of equalizing costs of electric power throughout the world. Distances will no longer be a factor when *pounds* rather than *thousands of tons* will supply the fuels for power generation. And it has been estimated that known resources of atomic fuels, as at present usable, can multiply the earth's fossil fuel resources at least 23-fold.

The aspirations of people for industrialization—in Asia, Latin America, and Africa, for example—are associated directly with the increase in power. To them it is the key to improved living levels. I am satisfied that atomic energy will fulfill such a role, ultimately.

For the immediate future the limiting factors include:

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1. The availability of essential atomic materials for electric power production.
2. The technical developments necessary for the utilization of nuclear energy.
3. The economics pertaining to the use of nuclear energy as compared to conventional energy sources.
4. The nature of the prevailing local economy in underdeveloped areas; the adaptability of the local economy to the use of electric power.
5. The ability to finance the required investment in electric power supply undertakings.

AVAILABILITY OF ESSENTIAL NUCLEAR MATERIALS

IF NUCLEAR ENERGY is to play an important role as a power source, adequate amounts of source materials—uranium and thorium—must be available. Although both of these elements were discovered well over a century ago, neither has been important from a commercial standpoint.

During the last 15 years, however, there have been ever-increasing efforts to find recoverable deposits and to devise new and efficient methods for processing the uranium and thorium-bearing ores. Much of the information concerning these matters—particularly the amounts of ore which have actually been processed—has been kept secret. The true extent of the world's nuclear resources remains somewhat of a question mark. It is important to note, however, that studies have indicated that the world's resources of atomic materials are vast indeed.

Numerous papers presented at the Geneva International Conference on the Peaceful Uses of Atomic Energy dealing with deposits and recovery of uranium and thorium show that vigorous efforts are being made to produce adequate amounts for peacetime purposes. The fact that uranium and thorium deposits are being discovered and that the ores are being processed in ever-increasing quantities indicates that sufficient amounts of essential nuclear materials for wide-scale power generation may be expected.

TECHNICAL DEVELOPMENTS

IT IS OBVIOUS that the usefulness of nuclear energy depends heavily upon our progress in technical developments. We must have reactors with the demonstrated ability to operate economically and in a manner satisfactory for electric power system service. This means that we must devise technology which will enable us to utilize a large proportion of the total heat potential of nuclear fuels rather than the very small part that it is possible to utilize with most reactors contemplated today. It also means that the technology must be such that power systems will not have to be dependent, for fuel, upon costly preparation and processing plants such as isotope separation plants, which themselves use up a tremendous amount of electric power.

It is true that, since atomic fission became a matter of widespread knowledge in 1945, there has been steady technological progress toward the development of practical methods of utilizing nuclear energy. We are still, however, some years from the time when nuclear reactors can be considered ready for use as a practical means of producing electric power.

For example, in the United States only a very few reactors have been built and operated for power production, and most of these have been small experimental units. Only one power reactor—the one which propels the submarine *Nautilus*—has been put to practical use. That unit is reported to be performing in an outstanding manner. But such information as is available indicates that if the *Nautilus* reactor were used for commercial power production, the cost of the electricity produced would be prohibitive compared to the cost of power produced by conventional methods. It is not clear at this time whether the *Nautilus* type reactor can be modified to make it more attractive from the standpoint of economics. This submarine reactor, however, does give assurance that the process of nuclear fission can be controlled.

There is a substantial program of reactor development under way in the United States which is expected to go far in advancing power reactor technology. About two years ago, the United States Atomic Energy Commission undertook a development program to build five different types of reactors. Last March proposals to build four large power reactors were submitted by power systems to the Atomic Energy Commission for its consideration as a part of a Power Demonstration Reactor Program. Other separate proposals to build large power reactor installations have also been submitted. Much information and experience which, no doubt, will lead to improved reactors acceptable for power generation will be derived from these various projects. It is important to emphasize, though, that all of the reactors involved apparently require enriched fuel and, thus, are dependent upon fuel processing operations for which only Government facilities are now available.

It is notable that two of the proposed reactors—one in the Atomic Energy Commission reactor development program and one in the Power Demonstration Reactor Program—are of the breeder type. These breeders will transmute more fertile materials (either U-238 or Th-232) into fissionable material than is fissioned in their operation. Such reactors require an initial charge of enriched fissionable material but subsequently should be able to produce enough fuel for their own operation as well as extra fuel for use in other reactors. This, of course, is dependent upon the development of economic fuel element processing methods.

Breeder reactors are the only type which can utilize a large part of the potentially available heat energy in the present atomic materials. Unless the breeder type of reactor can be successfully developed, it may be impossible to obtain enough nuclear fuels to meet the needs of a world-wide atomic electric power industry.

Obviously, important progress in power reactor technology is being made in countries other than the United States. Certainly, it may be said that the development of nuclear reactors for power generation is well under way and that reactor technology is progressing in several countries at about the same rate as in the United States. There is no assurance, however, that any of the reactors now being built, or now contemplated, will be sufficiently advanced in technology or low enough in cost to justify their universal use.

There is increasing confidence that the necessary advances in reactor technology will be achieved. Those actively

engaged in reactor development work generally agree that 10 years or more of persistent and painstaking work may be required. Within these 10 years a considerable number of reactors will be built. It is likely that most will be developmental installations, to permit study of the technical and engineering problems which must be met and to provide operating and maintenance experience. It seems plausible that subsequent installations made on the basis of this experience may be of practical and economic value.

The admittedly indefinite situation with respect to reactor technology makes it most difficult to predict the role of nuclear energy in the more distant future. Although within 25 years, let us say, nuclear energy will undoubtedly make tremendous progress, it seems unlikely that it will even then provide more than a relatively small part of the total energy consumption of the world. Within still another 25 to 50 years from now large-scale use of nuclear energy for the supplementation of conventional energy resources in meeting new power requirements seems reasonable.

ECONOMIC CONSIDERATIONS OF NUCLEAR ENERGY

Because of the deep hope that nuclear energy will lead to a better and fuller life, there is a natural inclination to overlook the economic aspects of its use in power generation. It is clear, however, from the practical standpoint, that the use of nuclear fuels can be justified only when the cost of power so produced is no greater than the cost with coal, oil, or gas, and preferably less.

So far as can now be seen, present practices in the power industry will not be changed materially by the successful development of nuclear fuels except in the matter of producing the thermal energy which is ultimately converted into electrical energy. We will continue to have power plants similar in most respects to the conventional fuel-burning plants used today, and containing to a considerable extent, at least, the same kind of equipment that is now used.

Though most authorities agree that workable methods of producing power with nuclear energy can be developed within the next 10 years, there is still serious question as to what the actual cost of such power may be. As has been stated, the large reactors now planned or under construction in the United States are developmental units, and it is generally expected that the power they will produce will cost more than that produced by conventional methods. It is believed possible that the second or third generation of reactors—through "built-in" experience, so to speak—may produce power at sufficiently low cost to make them attractive for use on a truly competitive basis. These reactors are already being contemplated.

It should be noted, too, that most of the reactors now being developed for power generation are much larger than will be required initially in many countries—larger than today's local power use would dictate. For example, the four reactors proposed for the Atomic Energy Commission Power Demonstration Reactor Program range from 100,000 to 200,000 kilowatts of electric capacity. They have been made large primarily because large units fit better into most existing power systems and because large units have a better opportunity of being competitive.

Although there is considerable activity in the development of smaller size power reactors, with capacities ranging from 1,000 to 25,000 kilowatts of electricity, it is difficult to evaluate the economics of such units at this time.

In general, economic considerations indicate that nuclear power plants, when they do become practical, will be used principally for adding new electric generating capacity to provide for load growth. It is highly improbable that any number of serviceable, existing plants will be displaced. The prospect is that most conventional plants will be used throughout their economic lives.

Evidence again seems to indicate that in the United States, except as nuclear power plants may be built to carry on developmental work, nuclear energy is not likely to be a major factor as a power source for at least 25 years. The uses of energy here are so great that it would be physically impossible to carry out the development work and at the same time build enough plants to supply any important part of the total requirements. Again, it would appear that if present development programs are successful, it is possible and probable that nuclear energy will become an important factor as a source of energy within 50 years.

In parts of the world other than the United States, the economics of nuclear power seem quite different. Because of the uneven distribution of energy resources, and many economic, social, and political factors, energy *sources* rather than energy *cost* are a limiting factor. In Great Britain, for example, which has comparatively large coal deposits, atomic power plants are already being built and programmed, partly because of difficulties in mining the coal at a sufficient rate to meet the increasing needs for electric power generation.

Such conditions, which are also to be encountered in other parts of the world, may bring about the earlier general use of nuclear energy. Such plants as may be built will be of great importance, but it is difficult to see how enough facilities can be provided to permit nuclear energy to fill a major port of the world's energy needs within 25 years. Fifty years hence still seems to be the likely point at which nuclear energy could be expected to supply the full additional requirements of that day in any part of the world. These needs taken collectively could be great indeed.

THE PREVAILING LOCAL ECONOMY

The nature of the prevailing economy in the various countries of the world and the adaptability of the local economy to the use of electric power are important factors in determining the role of nuclear energy in the years ahead. Where the pattern of power use continues low, nuclear energy probably will have a comparatively unimportant effect. Where the pattern of power use can be greatly expanded, nuclear energy can be truly important.

Most of those countries with advanced and expanding economies already have large, well-developed power systems. In such countries, the probable pattern of increased use of electricity is definitely established, and the successful development of nuclear power reactors may not be expected to change that pattern substantially. Rather, nuclear energy probably will be used to supplement present energy resources and give assurance that future growth in the use of energy can actually be supported.

In the United States, and in many other parts of the world, the use of electricity has been doubling about every 10 to 12 years. There appear to be sufficient fuel resources to maintain that trend for many years ahead, but the cost of those fuels undoubtedly will increase. When nuclear reactors are developed to the point where they can compete economically with conventional fuel-burning equipment, the atomic equipment may be expected to start relieving the drain upon fossil fuels.

Some areas—such as the United Kingdom, The Netherlands, and Denmark—already are well electrified, but lack additional and easily available energy resources. Under these circumstances, the urge to use nuclear fuels will be much greater. In Great Britain, competitive costs apparently are being partly ignored in order to meet the power requirements. In such areas, within 25 years, nuclear reactors might be supplying an important part of the electric power. And in 50 years they might be supplying a major part of it.

It is the areas now lacking well-developed power system that present the greatest problems in visualizing the future role of nuclear energy. There are only a few areas in the world today where power cannot be made available at a reasonably favorable cost. Considerations other than the availability of energy resources have been the basic cause of the present lack of power development. As previously explained, numerous other factors—financial, economic, and political—are involved.

Although nuclear energy may effectively remove the barrier raised by the lack of available energy sources, this does not of itself assure a large and immediate expansion in the use of electric energy in the less advanced countries. The very large use of power in the more advanced countries has come about by slow but continued economic advances over the past 75 years. This high power-use pattern has developed because the economic conditions within those countries permitted and encouraged the extensive use of electricity.

Many other countries where nuclear energy could be most helpful do not have, as yet, similarly favorable economies. In such places, tremendous changes must come before economies can be developed which are adaptable to the widespread use of large amounts of electricity.

Atomic energy has stirred the imagination of men more than almost any other subject in history. It has engendered a world-wide hope that the lot of all people can be greatly improved. This universal hope is, in itself, most encouraging and may speed progress in social, political, and economic affairs which can lead to the better world so fervently desired. It is a most noble objective.

Nuclear energy—of itself—cannot bring about these essential advances. But nuclear energy may well be one of the most important factors in making such social progress possible.

FINANCIAL PROBLEMS

If nuclear energy is to provide for the betterment of conditions throughout the world, some formidable financial problems will have to be solved. One of the most serious problems faced by many countries in providing a supply of electricity has been in obtaining the money required to build plants and erect lines. Within the past 10 years much needed programs involving conventional types of power plants have come to naught for lack of funds. There is urgent need for outside investment in most of these situations but it has been exceedingly difficult to make the necessary arrangements. Strong nationalistic tendencies to regard as "exploitation" the justification of a fair interest return on investment, seem to present the biggest problem. It is probable that funds could be made available if adequate assurances of the security of such investments could be obtained.

This is a most difficult situation, and up to the present time no full solution is evident. Because nuclear power plants will require comparatively high investment, this problem is all the more severe, and may greatly restrict the role of nuclear energy.

CONCLUSION

We have pointed out the increasing understanding of the close relationship between the utilization of energy and the progress and well-being of mankind. We have spoken, too, of the great expectations for a better, more peaceful, and more abundant world—the new hope for humanity that has been born of the scientific achievement of nuclear fission. The realization of this humane hope, as we have seen, is tied very closely to the development of atomic energy as a practical heat source for the production of electric power.

There is little doubt, therefore, that nuclear energy is virtually certain of a dominant role as a power source and as a prime influence upon world standards of living.

It is extremely difficult, however, to arrive at any accurate measure of world-wide usefulness of atomic energy because of the multitude of limiting factors which affect each country in different ways.

In the United States, the use of electric power will continue to increase and, at some time, atomic energy will be exceedingly useful as a source of energy.

In many other countries atomic energy may have even greater importance. Within a very short time it will be utilized in Great Britain to supplement hard-to-mine coal resources. Other countries are endeavoring to attain this status at an early date.

Norway and Sweden have no indigenous fuels and their power systems rely almost entirely on hydraulic energy. Nuclear energy there can be extremely important as a source of heat energy for industrial processing and other similar purposes in addition to the production of electric power.

The greatest opportunities lie in the underdeveloped countries. Whether there is sufficient will to overcome the many limiting factors cannot be foreseen at the present time.

Without question, atomic energy ultimately will have great usefulness throughout the world. Present indications are that such usefulness will be manifest in the increased availability of electric power which is well developed in some countries, and only embryonic in others.

Component Reliability in a Transmission System

W. VAN HASTE

ONE OF THE CHIEF FACTORS in establishing a reliable electronic system is to assure compatibility of the operating environment and the capabilities of the active electronic device. This can best be brought about by close co-operation between the equipment and component designers.

The *L-3* coaxial system was designed by the Bell Telephone Laboratories to meet telephone and television requirements in the growing demand for long distance transmission facilities. One transmission circuit is capable of handling 1,860 telephone message channels or one television channel and 600 telephone message channels. The transmission band is 300 kc to 8.35 mc, amplification being required every 4 miles. In a 4,000-mile system there are thus about 1,200 amplifiers in tandem where each amplifier employs five electron tubes as active devices.

In order to have a practical maintenance procedure, it is necessary to use plug-in amplifiers which in turn imposes a requirement of complete interchangeability. To achieve this goal within the tight system limits, it is essential that the amplifiers should follow a normal distribution pattern. The economical way to secure this objective is by imposing distribution requirements on the amplifier components. While only the electron tubes are discussed, similar considerations apply equally well to the coils, capacitors, resistors, and other circuit components.

The relation of certain basic system objectives to the electron tubes is as follows:

1. *Equalization.* Equalization is defined as the ability to maintain amplitude and phase of the transmitted signal at the receiving terminal. In broad terms, it is required that the average values of transconductance of the tubes be maintained close to desired nominals, that individual values be randomly distributed around these nominals, and that the reduction of transconductance with time be gradual (less than 3 db in 15,000 hours).

2. *Fidelity.* The fidelity of transmission requires at least a 40-db signal-to-noise ratio. This may be translated into the electron tube harmonic distortion requirements.

3. *Reliability.* The over-all reliability requirement for the 4,000-mile system is that not more than one major failure (loss of circuit for 4 hours or more) shall occur per year. Preliminary studies showed that such reliability with available components could be achieved only by providing automatic switching to a standby circuit. Assuming automatic switching, the over-all reliability objectives for electron tubes of the *L-3* system are: (1) sudden failures (glass cracks, open connections, interelectrode short circuits, etc.) shall not exceed one per thousand sockets per month and (2) average thermionic life should be at least 15,000 hours.

To meet the demands of this 4,000-mile transmission system three new electron tubes were developed by Bell Telephone Laboratories for use in the amplifiers. These are manufactured by the Western Electric Company under code numbers *W.E. 435A*, *W.E. 436A*, and *W.E. 437A*. All of these are high-transconductance tubes, the first two being tetrodes and the last one a triode.

The maintenance of distributed performance of electron tubes is directly dependent on the piece parts from which the tubes are assembled. Process controls are maintained on the physical dimensions of the cathodes, grids, anodes, etc., and also on the effects of chemical processes such as cleaning, coating, heat-treating, etc. For the new tubes for the *L-3* system, virtually every part and process has statistical controls applied to it.

A steady flow of normally distributed tube parts on the manufacturing line has permitted production of tubes that satisfy the design objectives. Since the characteristic of particular importance to the transmission system is transconductance, this parameter is required to meet strict limits in regard to the process average. To satisfy the system requirements, random shipment of tubes is permitted only if the process average is controlled within $\pm 1/3\ \sigma$ limits.

The life and reliability problems of the *L-3* system are coordinated by a committee comprising representatives of tube design, tube manufacture, circuit design, circuit manufacture, and system operation (the customer). The function of the committee is to act as a planning board and to review and disseminate information. The detailed work is done in smaller subcommittees.

The initial installation of equipment was in a field trial between Newark, N. J., and Philadelphia, Pa. The experience of this trial furnished valuable information concerning sources of trouble and emphasized the benefits of the committee operation. During this phase of operation it was possible to conduct designed experiments to ascertain the effects on tube life of different operating conditions.

The controls on the components have resulted in a supply of amplifiers that are completely interchangeable; there is no selection problem. The system reliability objectives have essentially been met in regard to tube performance. Sudden failures have been minimized through factory assembly and testing measures and, where necessary, by specification of additional requirements. Average life in the order of that required under reliability objectives has been achieved. This is based on end-of-life criteria that insure the objectives mentioned in connection with equalization requirements.

Digest of paper 56-86, "Application of Statistical Techniques to Electron Tubes for Use in a 4,000-Mile Transmission System," recommended by the AIEE Committee on Electronics and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956. Scheduled for publication in AIEE *Communication and Electronics*, 1956.

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Engineering Organization and Management in an Aircraft Equipment Company

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The highly competitive aircraft equipment industry must give more attention to the prestige of engineers in order to hold capable men for management as well as line organization.

LIKE ITS TWO SISTER BRANCHES of aviation, airline operation and airframe manufacturing, the aircraft equipment business is highly competitive, full of risks and market pressures. This sweat and pressure makes its engineering operation exciting and, instead of creating a dilemma, forces its progress.

Since manufacturers of airborne apparatus are always under pressure for tomorrow's "black boxes," it is timely to review certain of their management needs and problems in dealing with (1) the pressure or driving forces behind their engineering operation, (2) certain organizational factors frequently neglected, and (3) the department controls that are necessary in managing a complex engineering department as a business.

DRIVING FORCES BEHIND OPERATIONS

Anticipating the "Market." To succeed in the aircraft equipment business with its high obsolescent factors, it is constantly necessary to anticipate civilian and military needs to the extent that some important devices must be timed to lead the field. An engineering organization, to do this, must be flexible and must be built so that it includes not just a few "longhairs" and draftsmen, but built around far sighted planning staffs, developmental groups, applied research laboratories, flight research centers, and experimental laboratories. Staying ahead of the "pack" by anticipating the market is a planned operation motivated by a driving force for new products that is so strong that it governs the type, the size, and the technical stature of the engineering organization.

Keeping Up with the "Market." In addition to the aforementioned pressure to "stick your neck out," there is the "bread-and-butter" force which is a demand to engineer products quickly at impossible time schedules to meet today's market. It is this force that starts the factory going, pays salaries, and causes most of the trouble and strain, and at times hysteria, in engineering organizations.

It is this pressure that causes all-out efforts for "crash" programs. When such crash programs are successful, complications set in. For example, there is temptation to continue that type of operation for other projects because production engineering releases are still behind schedule, and, based on hope, the sales department sells some of next year's developments. At this stage, with too many crash programs, important future programs disintegrate into postponement, new crash programs lose their steam, and the priceless personal emotional forces produce an atmosphere of confusion rather than building teamwork and company strength.

In order for crash programs to be successful, they must move with enthusiasm from their start to their completion. This requires planning, forced decisions, and forced leadership rather than development "drifting." It is the forced decisions and breakdown planning to do things simultaneously that are important in keeping projects current with the market. The crash program, therefore, serves two purposes: (1) to expedite an immediate job, and (2) as a vehicle for training people to plan.

These driving forces are common in most industries today. The difference is the greater emphasis and increased magnitude of these forces as they are generated in the aviation industry. Inasmuch as both of them will continue year after year, more organized effort should be used to make these forces a source of teamwork and strength.

OFTEN NEGLECTED FACTORS

AN ANALYSIS of most engineering organizations will indicate good grouping of developmental and research sections but probably not apparent are these often neglected factors that build long-term strength into the organization:

Needs of Top Management. The engineering organization should primarily satisfy the needs of top management and, secondarily, serve as an organization to co-ordinate the activities of technical people to carry out effectively methodical development of the product.

These primary needs of top management include:

(1) *Accountability.* Irrespective of how well the engineering organization is planned or how well responsibility has been delegated, one of the major concerns of top management is accountability for carrying out a project. Accountability in this instance is more than the acceptance of responsibility by reliable and capable technical people. It is being held answerable for performance and for the "whys" and "hows." Accountability is getting jobs out of trouble and getting them finished within the time, cost, and customers' performance limits; all in accordance with management aims and judgment.

To effect such accountability, supervisors must be

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selected who are capable organizers, forceful molders of action, exceptionally alert, challengers of decisions, and analyzers of the reasoning behind every step of the development. Picking supervisors with these administrative characteristics requires thoughtful separation of the "men from the boys."

The logical step is to select only supervisors who possess the foregoing characteristics along with a strong personality. This is very seldom possible. In many cases, it is necessary for the next higher level of supervisor to assume responsibility. In cases where the project requires higher levels of supervision, accountability is accomplished on a task force basis by representatives from top management.

(2) *On-the-Job Control of Engineering Expenses.* Although engineering surveillance control groups perform a checking service, the real concern of management is for training to put across the idea to properly control cost at the working level. Waiting to do something until faced with the cost control balance sheet is not only procrastination but unrealistic management.

It is far better, therefore, to accomplish cost control by insisting that the supervisor administer as a business man with cost as part of his daily decision making judgment process. In administering he should always remember that one of his primary charges is knowing when to stop each item of engineering expense. He and the department should make use of cost control reporting and trends of costs, always remembering that such guides are a policing function rather than a management function.

(3) *Determining the Extent of Product Risks.* An important need of top management is the need to know the magnitude of financial and time risks involved in developing and keeping products in production. Factory contact groups. when they are alert, can aid materially in this function, These people as well as line engineering supervisors should look upon this upward reporting as routine duty rather than chance comments when they meet top supervisors in the hall.

Personal Recognition. Personal recognition when stripped down to the fundamental urge of human nature is nothing more than satisfying the individual's wish—look at me, I am important too.

To make use of the individual's feeling of importance and desire for "office" and relative rank in planning an organization structure, it is necessary to review a general concept and then call attention to specific factors and their effect on the organization.

The general concept is well presented by Peter Drucker's counselling, "promote the prestige and dignity of the engineer as a professional both inside and outside the organization"—build up the supervisor-engineer relationship to the extent that it is "much closer to that between the senior of a university and the young man on the faculty than between the boss and the subordinate." Thus, both the boss and the subordinate should have positions or "offices" of prestige and respect.

To management, the organization chart means methodical channels for operation. To the individual engineer this same organization chart is looked upon as a tangible expression of personal recognition. In view of this conflict of meaning between management and the individual engineer as to what the organization chart signifies, it is necessary that the organization structure and its "chart expression" include more opportunities for indicating to the engineer that he is an important part of the organization. Issuing subordinate organization charts will not suffice—the need is for more titles.

The organization should include more prestige titles such as Senior Design Engineer, Associate Development Engineer, Principal Engineer, Staff Electrical Engineer and other titles that connote the engineer's worth to the company and position of influence.

The assistance of specialists and the availability of technical information should be made convenient for the engineer in order that he can be more active in technical societies. This means supporting the engineer with the opportunity to participate in technical research projects, investigative studies, and standardization activities. With this support, the engineer is able to be active in technical societies by being an important participant and able to achieve national recognition.

The organization planning activity should establish policies for training programs that instruct the first-line supervisor in the art of delegation of special work as a means of recognition for the engineer. This includes setting the engineer apart from the group by allowing him important daily duties of responsibility for activities over which he has shown proficiency. Such activities not only provide recognition but also are very effective in unloading the supervisor. This is truly master-apprentice type training of "how it's done with respect for the engineer."

Although these factors on personal recognition are well known, there is a tendency to neglect their application—especially the establishment and designation of positions and titles until engineers are more advanced and design problems are straightened out. During this period of neglect, recognition trouble shows up every time a project is out of design trouble.

There are many cases in employment agencies' files that show the engineer seeks elsewhere what he does not find at "home"—recognition and appreciation. As a result, a talent scout offers him a position of engineering eminence in another company where he *thinks* he will be important and appreciated.

Building More Winners into the Organization. Probably the most important task in all organization planning involves arranging the organization to provide a workable means for the effective development of people. This task is difficult because first, it is in conflict with getting today's "bread-and-butter" engineering finished and second, this development of people is competing with the pressure to engineer new and novel devices that anticipate the aircraft market. Thus, it is small wonder engineering management finds itself in a 3-pronged dilemma. Doing something about this 3-pronged conflict can be the major problem in organizing an engineering department.

Although it is mandatory to build apparatus to survive, building people is necessary to perpetuate the business.

This fact is best remembered by the realization that if executives and engineers would periodically recall their past developments, they would realize that all they actually have to show for their work are the people they help build because most of the devices have long since been discarded to the "ash can."

Since building people is a long-range job in the engineering department, executives should devote more thought toward shaping the organization structure to provide opportunities for such development. This need becomes critical when the organization grows in size to include hundreds of engineers. As size increases, time for personal observations by top levels of supervision is not available to build the numerous people that are required. Some of the steps to speed up this development process are: placing emphasis on job rotation, frequent exchange of supervisors, and development by promotion. These are ways to increase the opportunities and the *rate* of acquiring experience.

(1) *Exchange of Assignments To Develop Responsibility and Growth.* It is advisable to have the organization so planned that lateral exchange of jobs and promotions can be made for the dual purposes of widening the individual's experience in executive responsibility and providing additional opportunity for practice and growth. This lateral exchange is something that should be contemplated and frequently practiced in normal balancing of the engineering workload to overcome reluctance to accept it.

(2) *Job Rotation.* It is frequently desirable to determine the individual engineer's weaknesses, strong points, activities of greatest interest and comparable dealings with varied groups of people, by introducing him through job rotation to the major engineering areas. By such job rotation it is possible to compare his performance and give a much broader evaluation and analysis of the individual's capabilities.

To make this rotation process effective, it is necessary during daily activities of the specific engineering assignment that the engineer have his strengths and weaknesses identified by specific cases or actions. These cases should be analyzed and then the individual counseled and trained in the correct procedure to satisfy the policies and aims of management. Attention on a once-covered basis is not enough in this area because habits are not easily broken. This requires follow-up and patience in building strong capable people.

(3) *Promotion.* In developing engineering and supervisory talent, perhaps the most daring yet entirely realistic organization development is the following method that was disclosed some years ago by a research study conducted by the Graduate School of Business of Stanford University. This study disclosed that frequently the greatest gains can be made by basing the job appointment on *what it will do for the man.* This study further disclosed that some companies find it very profitable to fill appointments from the lowest to the highest levels of supervision based not upon who can most quickly fill the job, but what "man... would get the most out of the appointment."

In this connection, it is important that the number of candidates available be increased at every opportunity by rebuilding those in the house as well as by acquisition of new personnel. To set the stage for this appointment method requires advance planning and shaping the organization first, to support such promotion and second, to provide training areas and observation areas to enable the men who "ran second and third" to enter the competition for additional appointments later.

Flexibility. Flexibility is accomplished by continually selling opportunities for more experience. This requires advance planning in setting up the organization and training the people to be accustomed to frequent changes that are well planned and "sprinkled" with opportunities.

The two pressures, mentioned at the beginning of this article, that give this business its ever-changing perspectives also make it mandatory that flexibility be built into the minds of designers and supervisors as well as into the organization structure. Inasmuch as changes, just to satisfy these pressures, do not produce inspired, versatile and contented engineers, enthusiastic supervisors, or new producing sections, it is necessary to achieve flexibility via personal appeal of opportunity.

The big problem in putting over flexibility is overcoming fear—fear of losing a "position of know-how." This applies to the supervisor, as well as to the engineer. This fear must be overshadowed by the assurance of better opportunities and training for more advanced work. Everyone likes to think he belongs because he is important, is wanted, and is somewhat indispensable. Through reassignments, most engineers lose their stronghold of specialized and sole-source knowledge; but by careful planning and help during such changes, they become versatile and, therefore, indispensable in a much broader sense.

Technical Strength. Whether the organization is built around technical groups or project groups or combinations, the technical stature and "depth" of the groups must be kept technically adequate to carry simultaneously both the short- and long-range programs. Adequate staffing does not mean giving project engineers everybody they want, but it does mean supporting projects and programs with additional people to be grown as a long-range planned operation in order to lessen the effect of "raids" every time a new project is started or a crisis appears in a production design. Raids are usually made on the projects that are least productive at the moment and are perhaps waiting for added manpower. This action obviously deteriorates such a project to the point it never gets done or it is placed on the critical list and a similar raiding process is repeated on an even more destructive scale. Adequate staffing, therefore, means backing up an organization with a planned means for growth and for perpetuating technical groups.

Perpetuation of development groups should involve the growing of engineers both in times of "feast" and "famine." As in any life cycle, people leave, and more and better people are needed to do their job. Therefore, irrespective of the engineering load at the moment, these "farms" must continue to be "planted" to grow engineers for tough design work in the years ahead. If the farm sections in

test laboratories and specialty groups start overflowing with growing engineers, it is always better to raise the requirements higher and start cutting out poor timber than to stop hiring new engineers.

Exercising leadership for growth purposes by purposely over staffing some projects and laboratories is a long-range planning activity, that requires continual follow through and selling by the chief engineer or director of engineering. In planning this activity, it should be remembered that the harm caused by bringing along too few engineers is more apparent to these men than to any executives in the company. These heads of engineering departments, therefore, must not neglect this important organization and management responsibility just because it is *not* a popular subject.

MANAGEMENT AND OPERATION

THE DIRECTION AND INFLUENCE of engineering management over the operation of an engineering department primarily relates to control, co-ordination and communication and follow-up checking in addition to organization planning. Since co-ordination and communication and checking are daily chores, not necessarily unique in the operation of an engineering department, the last part of this article will outline those controls most essential in making the department effective as a business enterprise.

Control Over Products To Be Developed. Control over products is twofold. First, it is important, in general, to limit engineering to those orders with "potential" to keep from engineering the company out of business on items that will die with the pilot order. Second, and even more important, is the leadership to be exhibited in selecting products that build adequate facility support to keep engineering expansion able to handle the long-range products that anticipate the market.

Development programs in most companies are tabulated to analyze projects in relation to manpower and funds, all with respect to finite time increments. In exercising this control, it is more important to remember that the preparation of such a program is more valuable than the program itself because it forces engineering decisions to take concrete form. These include defining the "unknown" and making commitments in terms of manpower, money, development time, and facilities.

Control and Authority of Engineering Activities. The theory behind controlling development charges should be for the engineer doing the work to establish definite commitment forecasts that indicate how much the project will cost, when it will be completed, and what its performance values will be in relationship to customer or company requirements. These questions are in line with standard business practices and should apply no matter how complicated or undefinable the project. Only when this basic premise is fully appreciated and respected, can control of the project be attempted and ultimately accomplished.

(1) *Work Authorization.* All work in the department should be authorized in portions, to limit dollar expenditure and to force periodic reviews and accounting of the work accomplished to date.

(2) *Design and Development Previews.* Probably the most important control that interests the customer is the review of the design and development by competent engineering supervision. Such reviews, if they are to be engineering refinement sessions, should be sessions where all engineering decisions and schemes are reviewed, challenged, and stand trial.

These design reviews do more to control the engineering department efficiency and maintain company technical leadership than all the other engineering controls combined. This is where engineering and factory cost reductions are most effectively handled and generally the last to be popular or practiced thoroughly because the job is hard work for the higher levels of supervision. Too many supervisors go through the motions of a design review without accomplishing its objectives. In setting up a design review, the senior supervisor should always remember that this is really the task that he was hired to do. This is the interjection of his engineering ingenuity, experience, and the application of his judgment to keep products better than competition.

Control Over Salaries. Keeping groups of engineering salaries in balance with the current labor market and inflationary trends is not much of a control problem today. The problem is the constant study to determine the individual engineer's worth to the company. Although there are some mechanized schemes for analyzing his technical competence versus current salary trends, evaluation is not a point rating or check-off list procedure. In the final analysis, the problem of granting fair salary remuneration is exercising mature judgment in evaluating the many characteristics of the individual in terms of technical labor market.

CONCLUSIONS

THE OBJECTIVES OF THIS ARTICLE were to present some of the thought-provoking organizational factors and controls that are basic planning activities involved in steering and building men and strong aircraft equipment engineering departments. Of secondary interest was the objective to bring out the salient points of the many competing interests that cause major engineering management problems.

An attempt was made to show that the important interests of both management and engineering people are compatible even though they compete for attention. By giving proper attention to all these interests and factors, it is possible for engineering managements to make use of the pressures and the demands for attention to build people and engineering departments that are strong, flexible, staffed with talent, and possess accountability to solve the aircraft industries' equipment problems.

REFERENCES

1. Top Management Organization and Control, **Holden, Fish, Smith.** A study conducted under the auspices of the Graduate School of Business, Stanford University, Palo Alto, Calif., 1941.

2. Incentive Management, **James F. Lincoln.** Lincoln Electric Co., Cleveland, Ohio, 1951.

3. The Practice of Management (book), **Peter F. Drucker.** Harper and Brothers, New York, N. Y., 1954.

A 72-Channel Radio System for Toll Telephone Service

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TO FILL A GROWING DEMAND for a medium channel capacity microwave equipment tailored to toll telephone service, the Type *72B* radio package has been developed. Requirements placed on this design have been: (a) wire line reliability; (b) toll-quality performance on noise and crosstalk; (c) integration into the telephone plant; and (d) adaptability to existing wire line carrier systems.

Present use by the telephone industry of 4,000 megacycles (mc), and planned use of the 6,000-mc band for heavy route large-channel groups led to the choice of the 900-mc band as logical for this medium-size system. At this frequency, some advantage is gained in reduced severity of fading.

The 5-watt transmitter uses the crystal-controlled Serrasoid system of phase modulation to achieve the exceptionally low distortion performance required. The receiver is a straightforward double-superheterodyne. To accommodate the 500-kc frequency deviation rating, the receiver bandwidth is about 2 mc. Maximum capacity of the system is 72 channels of single sideband telephone carrier. The usual antenna is a 10-foot parabolic reflector, having 27-db gain, which may serve up to 3 transmitters and 3 receivers by way of an appropriate combining filter arrangement.

To form repeaters, radio equipments are connected back to back. This form of repeater is especially desirable for the intended short-to-medium haul service where channel dropping and inserting is frequently a repeater requirement. Tones supply supervision, alarm, and control function information. Performance of the equipment is adequate for systems with up to about 10 repeaters, maintaining toll standards of transmission.

A complete duplicate radio system is provided optionally for emergency standby, if desired. The standby unit is left on at all times, and automatically restores the circuit in a fraction of a second in the event of equipment failure.

The noise contributed by this equipment consists of a combination of intermodulation distortion and radio noise. When there is no fading, the radio noise is negligible, modulation noise being the limiting factor which dictates the number of tandem sections permissible. Systems longer than about 10 sections should have compandored carrier channels to maintain toll-quality noise performance. On a well-engineered system, radio noise is rare, being noticeable only when serious radio fading occurs. Generous engineering in the equipment in this respect provides a fade margin of 44 db over a 40 mile radio section. The equipment is being used to meet a variety of problems. In one case, a radio link has provided circuits between Seattle, Wash., and Victoria, B. C., Canada, to replace previous facilities which included a circuitous land line and failing submarine cable. Other installations are being made in locations throughout the mountainous terrain of the Pacific coastal area, where wire line failures have been commonplace during the severe winter weather. Several installations are under way to provide communications service to new military bases remote from existing wire line facilities.

A number of these systems have been installed in the Hawaiian Islands where submarine cables have not been practical for interisland service.

Two 48-channel terminals, type 45BX carrier telephone equipment

Digest of paper 56-16, recommended by the AIEE Committee on Radio Communications Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956. Scheduled for publication in AIEE *Communication and Electronics*, 1956.

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Apparatus Noise Measurement

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AS THE AMERICAN STANDARD ASSOCIATION'S test code for apparatus noise measurement[1] is now considered obsolete, these data are intended to serve the electrical industry as a guide in the 1- or 2-year interim before publication of a revised American Standards Association (ASA) standard.

The most important revision will involve an emphasis upon the measurement of total sound power. Sound-pressure levels alone are usually inadequate and seldom offer a fair means of comparison of the noise of different types of machines. Also, once the sound power is known, it is possible to compute the sound pressure—within engineering accuracy—at any specified location in a given enclosure. Another important point is the fact that noise test codes, at a minimum, should be based upon measurements made by octave bands. Weighted network levels can never be satisfactory as no mere filter can weight the sound as the ear hears it.

Free Field Measurements. A space integration of the total sound power radiated into a free field is perhaps the most basic approach to sound-power measurement. This may be accomplished by means of a point-by-point survey of the sound pressure over the surface of a hypothetical sphere, or hemisphere, surrounding the device under test. The radius of such a sphere and the locations of the various microphone positions are of some importance though they are not highly critical, since the same acoustic power must pass through all concentric spheres. In general, the radius should be chosen to avoid the near sound field, and the microphone positions should be spaced as uniformly as possible over the surface of the test sphere. With regard to the first condition, a radius equal to twice the maximum dimension of the machine, or not less than 3 feet, is considered as about a minimum. The point arrays[1] have been suggested to meet the second objective. The number of points chosen depends upon the directivity of the source which, in general, increases markedly at the higher frequencies. Perhaps it would be best not to specify fixed locations as standard microphone positions, but rather set down rules from which optimum positions may be chosen for different types of machines. In fact, one of the basic advantages of the sound-power approach is the test flexibility in this respect. Actually, fixed discrete microphone positions are not required, and the use of automatic rotating devices may be preferable.

Regardless of what microphone positions are used, the objective is simply to obtain an average sound-pressure level over the chosen test surface. Denoting the average level by $\bar{L}_p$, the total sound-power level (in the frequency band under consideration) may be computed, from

$$\text{Sound Power Level} = L_W = \bar{L}_p + 10 \log S - 0.5$$

in decibels, referred to 10^{-13} watts, where S is the area of test surface in square feet. This reference base has not been standardized to date.

Reverberant Field Measurements. In a large reverberant enclosure, the sound-pressure level caused by a given sound source is essentially independent of position. Thus, for a calibrated reverberation room, the acoustic power of the sound source may be determined solely from the average sound level by means of the relation

$$L_W = \bar{L}_p + 10 \log R - 6.5$$

The room constant R may be computed theoretically, but is best obtained by use of a standard source of known sound-power output. This source may be a standard machine, the sound power of which has been accurately determined by a free-field integration procedure or from a test in a calibrated reverberation room, such as the Riverbank room or the Bureau of Standards room. Alternatively, a loudspeaker driven by octave-bands of monitored electrical noise may be used.

Semireverberant Field Measurements. Where, because of the lack of better facilities, it is necessary to make sound measurements in factory or laboratory areas, reasonably accurate results may be obtained by the following method: First, choose microphone positions which would be satisfactory in a free field, keeping as far from reflecting obstacles as possible. Then, measure one machine in the test room and also in a free-field—perhaps outdoors—using the same microphone positions. For each octave-band, determine ΔL, the difference in decibels between the average sound-pressure levels for the two tests, and compute R from

$$R = \frac{4S}{\text{Antilog}\left(\frac{\Delta L}{10}\right) - 1}$$

where S is the area of the surface, defined by the microphone positions, in square feet. Then, for any machine under test in this room, the sound-power level may be computed

$$L_W = \bar{L}_p - 10 \log \left(\frac{1}{S} + \frac{4}{R}\right) - 0.5$$

in decibels, referred to 10^{-13} watts. Actually, this method is fundamental and requires no decision regarding the state of the sound field within the room. The computations will automatically reduce to the free-field or reverberant-field equations, if either condition really exists in the room.

REFERENCES

1. Test Code for Apparatus Noise Measurement, *ASA Z24.7-1950*. American Standards Association, New York, N. Y., 1950.

2. Handbook of Noise Measurement (book), **Arnold P. G. Peterson, Leo L. Bernasek**. General Radio Company, New York, N. Y., 1954.

Digest of paper 55-725, "Apparatus Noise Measurement," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 3-7, 1955. Published in AIEE *Power Apparatus and Systems*, December 1955, pp. 1170-3.

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Why Ground?

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This brief summary of the sometimes misunderstood subject of grounding is from notes the author has used, and continually revised, for several years in discussion at inspector and contractor meetings in connection with National Electrical Code work. Although many safety problems are solved by grounding, it is pointed out that isolation or insulation, where it can be accomplished, may better serve the purpose.

THE TERM GROUND, i.e., to connect to earth in order to limit the voltage or potential difference to ground, is used broadly in the electrical trade. For instance, it is applied to electric circuits and devices in automobiles, planes, and other mobile equipment where it usually means interconnection of circuits or devices with the base or frame of the mobile equipment. Particular note is made of "grounding" as applied to mobile equipment, since the principal reason for grounding may be thus illustrated. Such grounding may serve all the intended purposes, limit the voltage of circuits, and avoid unnecessary difference of potential between adjacent surfaces.

In other words, the answer to the question "Why ground?" is "In order to avoid unnecessary and dangerous differences of potential."

TWO CONDUCTING SURFACES

HOW CAN DIFFERENCE of potential be avoided between two conducting surfaces? By simply short-circuiting them; that is, interconnect or tie together by means of a low-impedance circuit (Fig. 1).

Why low-impedance circuit? Because in case of current flow from one surface to another there will be a voltage drop directly proportional to the impedance. For simplicity, reference will be made only to resistance, although the same reasoning will apply for any combination of resistance and reactance making up the total impedance of the circuit. From Ohm's law: $E=IR$, the voltage difference between two points in a circuit will be equal to the resistance of the circuit multiplied by the current.

How does this come into grounding in the usual sense? Assume a conduit is grounded to a driven ground separate from the supply circuit (no longer permitted in the National Electric Code) having a resistance of 20 ohms, and an insulation failure causes a fault current of 6 amperes (maximum) to flow through to ground (Fig. 2). There would be a ground drop of 6 amperes × 20 ohms = 120 volts, which means, in this case, that the conduit exposed to contact would be energized at full line potential to ground and that the leakage current is too small to open the protective device.

Interconnecting the conduit with the grounded system conductor will reduce potential differences and will greatly reduce the number of failures. However, if a fault does occur, then protective devices will open (Fig. 3).

Full text of a conference paper presented at the AIEE Fall General Meeting, Chicago, Ill., October 3–7, 1955 at a session sponsored by the Committee on Safety.

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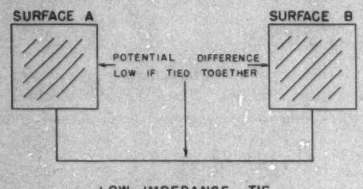

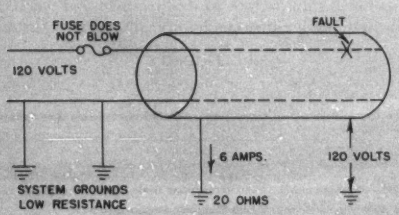

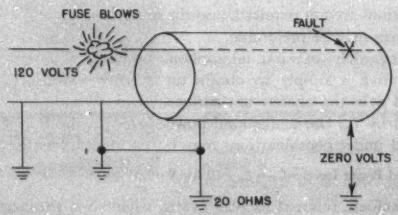

Fig. 1 (left). Low-impedance path between two conducting surfaces. Fig. 2 (lower left). High-impedance grounding. Fig. 3 (lower right). Low-impedance grounding

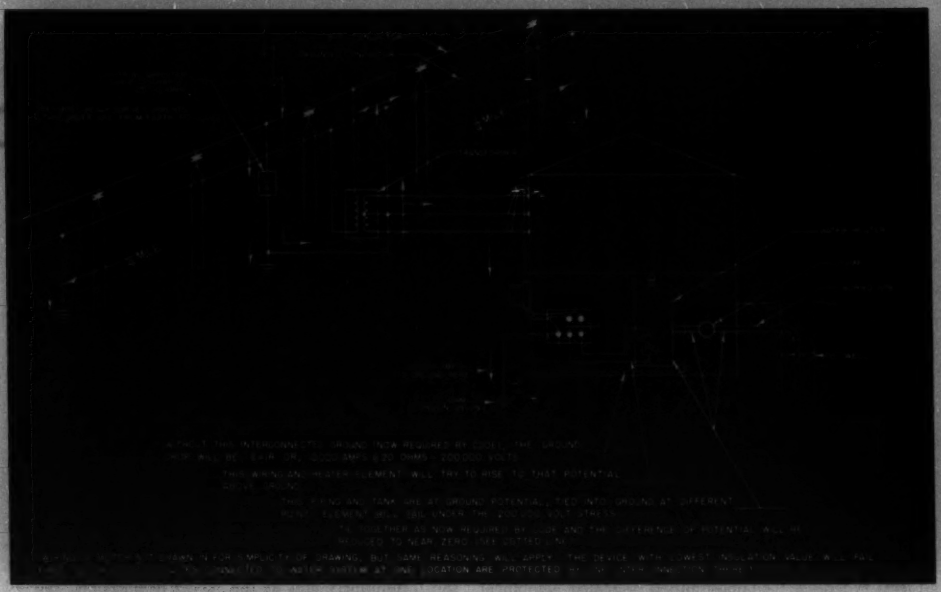

Fig. 4 Interconnected grounding eliminates unnecessary differences of potential

Also, for example, assume an electric range with the frame ungrounded and adjacent to a sink. Failure of a line wire to frame would leave full line potential between the range and the grounded sink, with no fault current (zero) until someone contacted the two. Then a small but dangerous and possibly lethal current would flow through the person's body, or some conducting object between the two might cause an arc and thus a fire hazard.

Therefore, it is necessary to tie the two conducting surfaces together by a conductor of low resistance and sufficient carrying capacity so there can be no objectionable difference of potential between them. Also, in case of fault, the current will be sufficient to open the protective device.

SERVICE GROUND

WHY SHOULD EQUIPMENT BE GROUNDED to the service ground? For the same reason given previously—to avoid unnecessary differences of potential, for protection of life, to avoid fire hazards, and also to save equipment. Without the interconnecting tie, a difference of potential caused by transient currents may lead to insulation failure.

Studies have shown that with a moderately heavy discharge of 25,000 amperes through the lightning arrester at the supply transformer, current in the order of 10,000 amperes will flow to ground at the customer's installation under usual circumstances. The balance will go through the ground at the transformer and other grounds on the primary neutral (Fig. 4).

Still referring to Fig. 4, assume an electric pump or water heater on an isolated water system. The service is grounded to a driven ground (in accordance with Code prior to 1951 edition). Assume a good ground resistance—about 20 ohms (lower than could be expected ordinarily). The water pump or heater is tied into a separate ground, incidentally, through connections with well and local piping system. A relatively small lightning discharge of 10,000 amperes goes to ground through the good ground of 20 ohms resistance. The result is that the electric system raised momentarily is 10,000 amperes $\times$ 20 ohms = 200,000 volts—but the tank of the heater or the frame of the motor still trying to stay at ground potential causes failure of insulation in many cases. If the incidental ground is of relatively high resistance, or even pretty good, about 20 ohms, there will be a good possibility that although the motor or heater has failed, the exposed frame will be at normal line voltage above ground. This is readily seen, since with 120 volts to ground and with 20 ohms resistance there would be only 120 volts/20 ohms = 6 amperes flowing to ground. This would be a maximum, further reduced by resistance of service ground. With about a 20-ohm service ground or a total resistance of 40 ohms, the current would be only 3 amperes—not nearly enough to take out protective equipment. Tie them together—all tanks, frames, piping, etc.—and there will be no objectionable difference of potential between them—in case of insulation failure, which should be rare, the protective device will operate.

Although isolated water systems were not at one time recognized for grounding, the Code now requires (Sec. 2581)

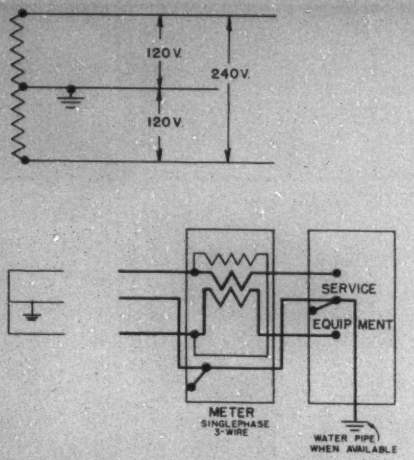

Fig. 5. Three-wire single-phase grounding

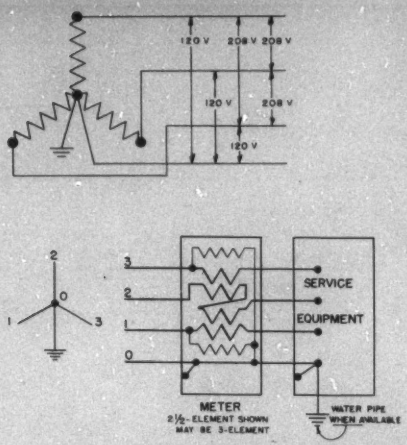

Fig. 6. Four-wire 3-phase wye grounding

grounding to the water system in all cases and a driven electrode, in addition, if buried pipe of water system is less than 10 feet. Whenever the opportunity is presented, equipment being added or wiring changes made on old installations with isolated water systems, they should be interconnected. By "grounding" the isolated system, not only is its resistance to ground reduced but it adds its weight to the electric-system ground network.

The principle is the same with all equipment—wiring enclosures, conduit systems, entrance equipment, meters and instrument transformers, etc. Any equipment that may be grounded incidentally, by being in contact with the ground or some other conducting system that is grounded—such as drainage piping, down spouts, gas piping, furnace ducts and piping, etc.—should be grounded to a common system ground.

When the equipment can be insulated or isolated from ground, as provided for in the National Electric Code, grounding is not required or necessary. This is particularly so, for instance, when portable equipment can be provided with an insulated case.

CITIES AND TOWNS

THE PROBLEMS in towns and cities are the same as in the country. The small amount of trouble usually experienced in cities is not because the problem does not exist, but because continuous underground water systems have long been used to ground all those things that need to be grounded. These pipes, in general, are all interconnected in the earth and provide a common low-impedance system to tie all other things together and to ground. In the country, the common grounding system is usually provided by the distribution system, frequently through interconnection of the grounded primary and secondary neutral conductors. Where the primary supply is from a system not having a grounded conductor available at the point of connection of the transformer, protection for grounded equipment can still be obtained by grounding the secondary at the transformers and at the service connection, and all equipment grounded to the service ground (Article 250 of Code). Most buildings contain water piping which must be used as one ground electrode—the piping throughout the building may be used to ground equipment that is required to be grounded.

In all cases, it is necessary to be on the lookout for insulating joints in piping at water softeners, washing machines, isolated pumps that may be connected by insulating joints, and in some cases plastic, transite, or other nonconducting pipes used for water services. It is not only necessary to see that there is not an insulating joint between the ground connection to such a pipe and the common interconnection with electric system, but also that all metal piping beyond such joints are grounded. A "dangling" water system can be just as dangerous as an ungrounded electric system. If the water system is not tied together and to the electric system, heavy arcs between parts of the systems may result, causing damage to buildings and failure of equipment. One system is as much responsible as the other for lightning damage inside buildings.

The proper grounding of utility distribution lines and equipment is provided for and, generally, well understood. There are, however, too many times when that part of the system that extends to the customer is left to the customer's electrical contractor and the inspector, who may know what to do and still not be able to provide the proper co-ordination.

The Code has now for 40 years required the grounding of single-phase a-c circuits (Fig. 5) and today they present no problem and generally no trouble is experienced up to the meter and service equipment. Considerable difficulty has been experienced where equipment, such as water heaters, pumps, etc., is not all grounded to the same service ground.

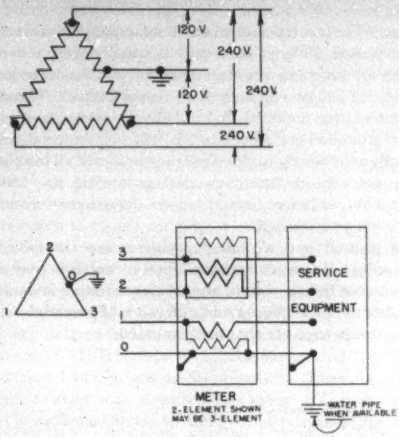

Fig. 7. Four-wire 3-phase delta grounding

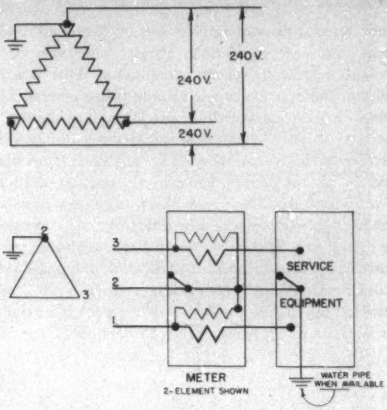

Fig. 8. Three-wire 3-phase delta grounding

The 120/208- and 277/480-volt 3-phase 4-wire wye systems and the 3-phase 4-wire delta systems (Figs. 6 and 7) are now getting better attention in the Code and its field applications. These present little problem since they offer a logical neutral point for grounding and the grounded neutral is extended to the customer's installation, providing a common point for "interconnection" of equipment grounds.

This leaves then, in the generally used low-voltage services, the 240- and 480-volt 3-phase 3-wire delta systems (Fig. 8). When such systems are grounded, the midpoint of the transformer is most generally selected as the ground point—following the old rule, the point giving the lowest voltage to ground. (It should not be implied, however, that all such systems should be grounded. There are applications for ungrounded systems, and all such installations should be properly safeguarded in accordance with the Code and with the advice of the supplying utility company.) This would probably be the most suitable provided a grounding conductor was extended from this point to the customer's service equipment to make available a common interconnecting ground point. This plan involves economic considerations—requiring the customer to run an extra conductor and the simple 3-phase 3-wire meter is not generally considered suitable, even though only 3-phase 3-wire load is taken from the service. A number of utility companies have in the last 25 years adopted the practice of grounding the corner of delta banks because of the simplicity of obtaining "interconnected equipment and system grounds" and experience reported to date has been satisfactory.

CAUTION: In any case where it is desired to change existing 3-phase 3-wire delta installations to corner grounding, careful test should be made to be sure existing equipment is free of accidental internal grounds. Fuses should not be installed on a grounded conductor from the ground point at transformer up to service equipment. A grounded circuit conductor should never be used beyond the service equipment for grounding purposes (an open conductor would leave equipment at line potential). This applies to all classes of circuits including single-phase, except for ranges and clothes dryers as specified in the Code—here runs are short, equipment is fixed in place, and little current carried by the neutral.

LIGHTNING ARRESTER

THIS DISCUSSION does not propose to cover the application of lightning arresters; there are circumstances where they will be found essential—generally, used on distribution voltages, 2,300 volts and higher, and frequently used on ungrounded lower voltages. In general, however, under 600 volts, where complete interconnected grounding can be accomplished, they are not found necessary.

When the interconnected primary and secondary grounds were being adopted as standard for rural lines in the early 30's, the meter engineers were disturbed about the effects of heavy lightning discharge currents through the neutral in the vicinity of the meter, affecting the damping magnet and, therefore, the accuracy of the meter. This problem was solved by co-operative work between the meter committees and the meter manufacturers, and all American-made meters have been provided with "protected" magnets, alnico, or copper-plated steel for the last 15 years.

In a sense, then, the watt-hour meter has been fixed so that surge currents of the magnitude usually encountered do not affect the accuracy of the meter, so interconnected grounds may be used for protection of insulation.

Based on a request from the utility companies for a Code change to permit 480-volt self-contained meters to be installed ahead of overcurrent protection, the Code committee acted favorably and the change was made as it now appears in the current (1953) edition (Sec. 2375e). The Code panel, on the recommendation of the National Meter Committee, included the requirement that when installed ahead of over-

current devices, the meter enclosures be grounded to a common system and equipment ground electrode or to a grounded neutral or system conductor. This was based largely on the experience with single-phase meters. There are now in service somewhat over 20-million meters "new sequence" or ahead-of-overcurrent device, and practically all grounded to the neutral conductor. Since these were installed within the last 20 years, or an average of 10 years, this means there are 200-million installation-years experience—with practically no difficulty. A large part of these meters are 240-volt single-phase; the experience with a considerably smaller number of 240-volt polyphase meters, not consistently grounded to system grounds, is not generally as good, although the insulation of the coils is in the same order and in some types exactly the same as the single-phase. The insulation level on all self-contained meters falls in the same 600-volt class and is usually well above the 2,500-volt acceptance test-level needed, so it is not the service voltage of 240 or 480 volts that causes failure. Therefore, the committee reasoned that if 240-volt meters gave service when grounded to system grounds, 480-volt meters should be equally satisfactory under similar conditions. This change does not require interconnected grounding for 480-volt meters but, as before, would require overcurrent protection when not so grounded.

As pointed out, all safety problems are not solved by grounding. In some cases insulation or isolation may serve the purpose better—but if, and when grounding is done, remember the principle—avoid difference of potential—tie all those things together that are grounded.

Complete Ship Wiring Using Mineral-Insulated Cable

L. M. GOLDSMITH
FELLOW AIEE

Three Belgian-built ships, the first constructed in accordance with American requirements using mineral-insulated metallic-sheathed cable and the first in the world using this cable for all purposes, will go into service in the near future. It is predicted that eventually land installations of wire and conduit will be superseded by metallic or other similar acceptable cables.

THE DEVELOPMENTS of the previous 40 years in electrical engineering as it applied to marine installations generally, and in particular as the art progressed in its application to tankers, was reviewed in our paper, "Forty Years of Electrical Engineering Progress in Tankers," presented at the Marine session during the AIEE Winter General Meeting two years ago.

Changes that had taken place in distribution systems on board a ship, particularly where wiring in conduit and in molding has been replaced by marine-type wire and cable, were described.

Also outlined was our method of detailing cable layouts and installing varnished cambric insulated lead-covered bronze basket-weave armored cable which has been used with considerable success on all our ships and tug boats for many years. In addition, the following statement was made: "With today's high labor and material cost, it would be well for those who are responsible for both shore and marine installations to study carefully the comparative costs between a standard land installation of conduit and cable and a normal marine installation of armored cable, inasmuch as under certain conditions it is conceivable that the marine-type installation can be justified economically over the conduit and cable. Based on work over this period of years in electrical installations, the prediction that land installations now will follow marine installations and use cable instead of wire and conduit is ventured."

At present, the use of armored cable for plant and building wiring has increased tremendously, and economics point to a continuing expansion of its application. Our experience with marine-type cable has been excellent, but better, more economical, safer, faster, improved wiring, and installation methods are continually being investigated.

The possibilities of mineral-insulated metallic-sheathed cable, as seen in use in England during World War II, was given serious consideration for use throughout ships, when our Seaman Class vessels were in the design stage in 1949. However, there were a number of reasons that prevented our making such an installation, not the least of which was lack of approval at that time by AIEE, American Bureau of Shipping, and the U. S. Coast Guard.

In order to obtain some experience with this type of cable

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The author wishes to express appreciation and thanks to M. Eichinger of the Societe Alsacienne de Constructions Mechaniques, originators and French manufacturers of Pyrotenax cable, and to the General Cable Company for their assistance during his study of the use of *MI* cable and in the preparation of this paper.

and to satisfy ourselves that it could withstand the rigors of a typical refinery installation, which is perhaps tougher than a marine installation because of corrosive atmospheres, an installation at our Philadelphia Refinery was made. This was done in 1950 and has been completely satisfactory.

BELGIAN-BUILT VESSELS

THIS ARTICLE discusses mineral-insulated metallic-sheathed (type *MI* or Pyrotenax, as it is called in Europe and the United Kingdom) cable in general, and in particular with reference to its use on three 18,700-ton turbine gear-driven single-screw vessels which our company is building in Hoboken, Belgium. These tankers are being built under the inspection of the American Bureau of Shipping. The electrical installations must conform to U. S. Coast Guard Regulations and must be in accordance with recommendations of AIEE Standard 45, "Recommended Practice for Electrical Installations on Shipboard." They are the first built to American requirements using *MI* cable and the first in the world to use *MI* cable for all purposes (Fig. 1).

The electric power plant of these ships consists of two turbogenerators each nominally rated 500 kw, 450 volts, 3 phase, 60 cps, 1,200 rpm, with a 2-hour overload rating of 125 per cent. There is also a 125-kw diesel-driven emergency generator.

In conformity with a practice established for tankers of our own design over 30 years ago, the cargo pumps are driven by electric motors. There are four of these pumps with motors rated 290 hp, 440 volts, 1,725 rpm.

The total installed motor horsepower is approximately 2,000 hp with 75-kva lighting transformer capacity, and 100-kva miscellaneous load including electric ranges, bake ovens, and other galley equipment. The nominal sea load is between 250 and 300 kw.

CABLE INSTALLATION

THE ORIGINAL SPECIFICATIONS for these Belgian-built tankers required "all electrical wire and cable to be leaded in basket-weave armor with varnished cambric insulation." However, since European cable vendors could not easily manufacture marine cables to meet the prevailing (1951) AIEE Standard 45, thus it appeared that it would be necessary either to accept European marine-type cable which was not too acceptable because of its weight, bulkiness, and perhaps general inferiority, or else pay a premium for cable that would meet our requirements.

Faced with this situation it was proposed, as an alternative, that the shipbuilders investigate the use of Pyrotenax (*MI*) cable for all purposes—power, lighting, control, intercommunication, and navigational aids (Figs. 2 and 3).

It was decided that a Pyrotenax cable installation would meet the severe demands of marine service and, in the range of its application, provide many advantages over leaded and armored varnished cambric cable. For these ships, it was decided it would make a dependable installation; therefore, the specifications were amended to allow the use of this type of cable.

The shipbuilders investigation and our studies indicated an installation of mineral-insulated copper-sheathed cable could be justified economically, since it was readily available in Belgium and France and, thus, would cost less money than the cable specified. Also, it would save considerable weight and space, take less time to install, and require less labor. This was borne out by a cost reduction allowed by the shipbuilder when Pyrotenax was agreed upon for installation.

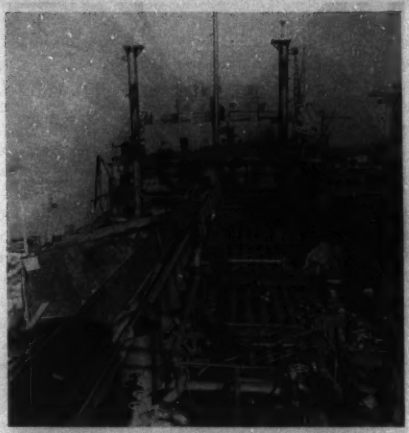

Fig. 1. Cable installations on shipboard

The use of *MI* cable for all power and lighting on these vessels is another step ahead in the art of marine electrical engineering and, as it is not strictly a marine development, fortifies the prediction that eventually more and more land installations of wire and conduit will be superseded by metallic or other acceptable sheathed cables.

TYPE *MI* CABLE

MINERAL INSULATED metallic sheath cable is relatively new in our country, although used commercially in France since 1934 and in England since 1937.

AIEE standard 45 (¶ 18.30) defines this cable as follows: "Mineral-insulated metal-sheathed cable is a cable in which one or more electric conductors are insulated with a highly compressed refractory mineral insulation enclosed in a liquidtight and gastight metallic tube sheathing."

For a long time the electrical industry has known that certain minerals and mineral-like materials, such as magnesium oxide, aluminum oxide, asbestos, and powdered glass have properties that make them good insulators. However, because of the nature of these materials, in order to properly use them for insulating purposes, it is necessary to contain them in some sort of protective enclosure. At the present time, the best materials found from both the manufacturing and operating standpoints are magnesium oxide for the insulant with high-conductivity copper for both the conductors and sheath.

There have been *MI* cables made abroad with aluminum conductors and aluminum sheath, and copper conductors with aluminum sheath, while in this country some small amount of the same type of experimental cables have been

Fig. 2 (top left). Cable way in lower engine room. Fig. 3 (top right). Cable outside amidship house. Fig. 4 (left). Cable on fore and aft walkway

made. However, the most satisfactory and generally accepted cables, here and abroad, are those made with copper conductors and copper sheathed.

CABLE MANUFACTURE

THE MANUFACTURE of this cable is difficult, as well as unique, and consists of two steps. The first step is the fitting together of the three principal parts (the sheath, the insulant, and the conductor); the second step is the drawing to size. In the first step, there are two methods of assembling the parts: the original method as developed by the French in 1934, and a newer method developed by the British to conserve manufacturing space and to increase production.

The original process starts with copper tubes from $1^3/_4$ to $2^3/_8$ inches in diameter, which are filled with blocks of pure magnesium oxide previously formed in powerful hydraulic presses. One or more solid copper rods are threaded through holes in the magnesium blocks.

In the more recent process, the conductors are placed in the tube, automatically jigged to their exact position, and then pretreated dehydrated magnesium-oxide powder is fed into the tubes and around the conductors, while pressing and tamping to the correct density.

The second step of drawing to size is the same for whichever primary method is used. This is the same as employed in conventional wire drawing. Between dies, intermediate anneals are used to keep the copper soft. After the initial drawing, the sheath, the insulant, and the conductor become one homogenous whole and maintain their proportion and relative position until the finished size is reached. After coiling, there is a final deep anneal to normalize internal stresses and to assure thoroughly soft copper for easy handling during installation.

CABLE SIZES

THERE ARE SLIGHT DIFFERENCES in wire size and over-all diameter between American and European cables; however, since these ships are being built to American requirements, tables and data from AIEE Standard 45 are used in our comparisons.

The *MI* cables are rated 600 volts and less, and are made in five groups of conductors: single, 2, 3, 4, and 7. (In Europe, Pyrotenax cable is rated 750 volts, and there are available 12-conductor control cables.) The number, size, and length of conductor in each group are limited by the mass of the three components (sheath, insulant, and conductor) with which the manufacturing process starts. Since this mass varies over a limited range, the length of large cables is shorter than that of small cables, and the number of wire sizes and length of multiconductor cables are restricted.

Table 41, AIEE Standard 45, gives dimensions, weight, and the maximum current-carrying capacity of *MI* cables for the five groups of conductors listed. Three of these groups (single, 2, and 3 conductor) may be considered for power purposes only, while the other two (4 and 7 conductor) are principally considered for control or indicating circuits.

In this table, a single-conductor cable is given in practically all the conventional American Wire Gauge (AWG) sizes from 14 to 4/0 inclusive, and there are listed seven AWG sizes from 14 to 4 in both 2- and 3-conductor cables.

There are only two 4-conductor AWG sizes (14 and 12) and one 7-conductor AWG (16) size given. In this table, there is no current rating given for the 4-conductor sizes, so it can be assumed that they are for use only on control or indicating circuits.

There are other sizes in 4- and 7-conductor cables, than those given in Table 41, being manufactured in this country and abroad; however, since they are not listed in the table, they are not approved by the AIEE Marine Transportation Committee and are not recommended for use on board American ships. It seems, however, that sizes larger than those given in this table should be included.

The current-carrying capacities, as given in Table 41, for power cable are generally higher than ratings given for

rubber in AIEE Standard 45, Table 9, Wire and Cable, but usually are 5 to 15 per cent lower than varnished cambric, and as much as 37 per cent lower than asbestos varnished cambric.

It is true that the limiting temperature feature of the *MI* cable is the termination, but since the maximum allowable conductor temperature is 85 C, which is the same as for varnished cambric insulated cable, it appears to us that the current ratings given *MI* cable in Table 41 are too conservative.

As another interesting sidelight, Lloyds of London allow a current capacity comparable with those shown in Table 9 for asbestos varnished cambric. Opinion is that when a successful high-temperature termination, particularly in regard to sealing compound, is available for *MI* cable, there will be nothing to prevent the satisfactory use of this cable with a similar rating wherever asbestos varnished cambric can be used aboard ship. This will mean, however, that existing standards, AIEE and U. S. Coast Guard (USCG), must be revised.

In regard to the current capacity of this cable, there is, of course, another consideration in determining the correct conductor size, which is the voltage drop that will occur under normal operating conditions. Section 21, AIEE Standard 45, describes the methods of distribution and limits the voltage drop on various circuits. Where circuits are long and heavily loaded, the conductor sizes are usually determined by voltage drop rather than by the current rating of the cable. A cable with high thermal capacity, such as *MI* cable, requires particular consideration.

COMPARISONS

A RESTUDY indicated the use of Pyrotenax cable on our Belgian ships was justified on economic grounds, that is, the actual cost of purchase and installation would be less than if European cables manufactured to our original specifications were supplied. It was also found that the same would be true if American leaded and armored varnished cambric cables were purchased at prevailing prices.

In order to be certain that a Pyrotenax installation would perform satisfactorily, it was essential that the electrical and mechanical properties of this type cable should be investigated thoroughly.

Electrically, the investigations indicated the cable would be entirely satisfactory. Insulation resistance of properly dehydrated and compressed magnesium oxide is much higher than most organic insulating materials, and this insulation changes comparatively little with temperatures up to 250 C.

The dielectric constant varies slightly with the insulant density. It is relatively constant for temperatures up to 300 C, and is not affected by frequency variations. The 60-cps dielectric strength of 60 volts per mil at room temperature is lower than most insulations. However, the breakdown voltage of 3,000 to 5,000 is adequate for 600-volt cable.

The high-potential test voltage of 2,500 volts is comparable to AIEE Standard 45, Table 34, "Requirements for Asbestos Varnished Cambric and Asbestos Semi-Plastic Heat and Flame-Resistant Cable."

Mechanically, the cable is ideal. Within the available conductor size range, Pyrotenax cable is hard to excell; it will withstand bending, twisting, hammering, and abuse that is the usual part of shipyard installation procedure without adversely affecting its electrical characteristics, and it does this to a greater extent than lead-covered or even armored cable.

In addition, the weight of comparable leaded and armored rubber or varnished cambric in all the sizes and groups is considerably greater than *MI* cable. A comparison of Tables 25, 26, and 27 of AIEE Standard 45 will disclose this cable to be $1^3/_4$ to 3 times heavier than *MI* of comparable size and group. Reinforced rubber sheathed and armored varnished cambric cable is from slightly heavier in the largest 1-conductor sizes (4/0) to three times heavier in the smallest 1-conductor sizes (12) and from two to three times heavier in the 2- and 3-conductor group. The weight of impervious sheathed and armored cable, either rubber or varnished cambric, though slightly greater is comparable to *MI*.

The outside diameter of all the aforementioned marine cable in all sizes and groups varies from $1^1/_2$ to 2 times larger than the corresponding *MI*. AIEE Standard 45 (¶ 20.09) recommends the radius of leaded and armored cables to be not less than 8 diameters and other cables to be 6 diameters, although the Standard (¶ 20.23) recommends *MI* bends to be not less than 5 diameters. Thus, *MI* results in a more compact space-saving installation that is especially valuable in close clearance areas.

One interested in the electrical installations on shipboard appreciates how much weight and space saving mean during the building period and, especially, how much weight saving mean to the operators. It is difficult to evaluate the building period savings exactly; however, it is safe to assume that every ton of cable weight saved means seven additional barrels of cargo that can be carried. The data given in Table I show an estimated weight saving of 10 tons, which can be translated into an increase of 70 barrels in the ship's cargo carrying capacity. The data give design lengths of each conductor group of cables, estimated weight of each group, and estimated weight saving made possible by the use of Pyrotenax cable, rather than leaded or armored varnished cambric.

DISADVANTAGES

THE *MI* CABLE is not the perfect cable; it has its shortcomings, which, if not given proper consideration, can result in an unsatisfactory installation. The principal inherent imperfection is the magnesium-oxide insulant which is hygroscopic and will absorb water to saturation. This will reduce the dielectric strength and allow current to flow through the insulation, ultimately causing cable failure. This defect can be avoided by careful handling of the cable to prevent exposure to moisture. However, if exposure occurs and moisture enters a cable, the rate of penetration is relatively slow, and the absorbed moisture can be completely eliminated by carefully playing a soldering or welding torch over 6 or 12 inches adjacent to the exposed end. If the run of cable is long enough, the defective end can be cut off. The condition of the insulant can be readily de-

Fig. 5 (left). Cable entering newel post from walkway. Fig. 6 (top). Cable entering outlet box

termined by use of a 500-volt megger, since thoroughly dehydrated magnesium oxide has very high insulation resistance, and low megger readings indicate moisture.

Another inherent drawback, because of the present manufacturing processes, is the varying lengths in which the cable must be manufactured. As explained, the mass of the three components (sheath, insulant, and conductor) at the start of manufacturing does not change greatly for the different cables. Therefore, the lengths of the various groups and sizes vary with the gauge and number of conductors.

The nominal coil length as established in AIEE Standard 45, Table 41, varies from 150 feet for 3-conductor #4 to 1,650 feet for 1-conductor #14 cable. This means that greater care must be taken when cable runs are laid out in order to eliminate splicing and, at the same time, make certain that waste and unusable lengths of cable are kept to an absolute minimum.

Present standard terminating fittings are the reason for the maximum continuous operating temperature of 85 C on these cables. The sealing compound and the insulating materials used on the terminals cannot be employed in areas of higher temperature. Therefore, they limit the use of *MI* cable to this temperature, where otherwise the cable could be used satisfactorily at much higher temperatures.

The use of scarce copper for both sheathing and conductors raises the question of availability of this type of cable, especially in the future. There has been a scarcity of copper in this country, which together with restricted production facilities would lead one to expect only a limited amount of *MI* cable to be available. However, present shipping promises are comparable with other copper cable. In Europe, there has been no scarcity. The cable is a standard item, manufactured in both England and France, and in both countries is readily obtainable.

Table I. Type MI Cable Data

Number of Conductors	Total Length MI Cables (Feet)	Total Weight MI Cables (Pounds)	Estimated Weight of Leaded and Armored Varnished Cambric Cable (Pounds)	Estimated Weight Saving (Pounds)
1	8,262	4,290	8,580	4,290
2	45,934	3,870	16,680	12,810
3	8,942	2,650	3,200	550
4	2,074	420	1,200	780
7	885	265	745	480
12	1,389	820	1,900	1,080
Total	67,486	12,315	32,305	19,990

In order to assure availability of repair cable, arrangements are made to carry on each ship one length of cable of each size needed. This length is to match the longest run of that size cable on the ship. In addition, there will be carried on each ship, two terminal fittings of each size with accessories. Carrying this spare cable and terminals on board ship should not be considered to be either unusual or an added expense, since it has been our practice for a long number of years to stock spare lead and armored cable for all other ships, and the practice was found to be sound.

REQUIREMENTS

Specifications require all cables to be installed in a neat and workmanlike manner, in single layers only, and in continuous lengths with no splices, regardless of service, avoiding crossovers wherever possible. If thought is given to the original layout, and a little care exercised during installation, a very good-looking workmanlike job that has symmetry and beauty as well as utilitarianism will result.

Originally, it is required that the cable be mounted on a $^{3}/_{16}$-inch steel backing plate with $1^{1}/_{4}$-inch lead-lined steel hanger straps spaced not more than 14 inches apart for support, except in the exposed areas (decks), where lead-lined brass supporting straps to prevent either abrasive damage caused by vibration or corrosive damage caused by salt water are required.

Requirements have been relaxed to allow perforated steel trays instead of the $^{3}/_{16}$-inch solid steel backing plate, in order to conform to European practice. In addition, brass straps in sheltered areas are allowed to be used without lead lining, because the cable inherently possesses considerable mechanical strength and, in our opinion, would not be affected by ship's vibration in these areas.

The perforated steel trays are mounted on stools to allow painting behind them and, thus, prevent corrosion in these areas. All straps are fastened with round head brass machined thru-screws, which are double nutted. Tapped holes are allowed only with specific approval.

Where cables pass through steel beams or structures that are not watertight, the openings are lead bushed or otherwise protected to prevent chafing. Where they pass through decks or bulkheads, which must be watertight, brass stuffing tubes are used.

In back of the main switchboard and group control panels, the shipyard cuts openings through the deck. Into these were brazed brass plates onto which were screwed stuffing tubes. The Pyrotenax cable was passed through these to eliminate any possibility of eddy currents from the 1-conductor cables. There are a few isolated circuits, which pass through steel structures where the steel was slotted between conductors to break up the magnetic circuit.

Beginning with our Van Dyke class tankers (1937), it has been the practice to run all the deck cables between the poop and amidship houses on the inboard side of the fore and aft "catwalk" bulwark, which on our ships are solid

plates rather than stanchions and chains (Fig. 4). On these ships, corrosion developed between the cables and the bulwark, and there was a great deal of trouble with cracks in the lead sheath caused by continual flexing and bending.

On our Seaman Class vessels (1950) the corrosion was eliminated by using a stainless-steel bulwark on the catwalk, and the flexing and bending difficulties were corrected by the use of three large radius expansion loops in the stainless-steel bulwark at equidistant points between the poop and amidship houses.

On these Belgian-built ships the practice of running the deck cables from poop to amidship house on the inboard side of the starboard bulwark has been continued. However, stainless steel was not used for the bulwarks, and in order to prevent corrosion underneath the cables and cable supports, the bulwark was given a 20-mil coating of neoprene along its entire length. Considerable attention was given to working out various details before applying the neoprene coating in order to be certain of the proper preparation of the steel plate, after which six separate coats were rolled on so as to establish the final minimum thickness of 20 mils.

In order to prevent cable damage by bending, flexing, and thermal expansion of the bulwark, two expansion loops, similar to those proven successful on the Seaman Class vessels, have been provided, one at each end of the catwalk, so located that each loop is equidistant from its end and the center of the catwalk.

Novel structures, called "newel posts," are located at each end of the catwalk for entrance of cable to amidship and poop front houses (Fig. 5). Considerable thought has been given to the design of these structures to secure complete watertightness and to make certain the symmetry and order of the cable runs are maintained from the engine room to their terminations. Also, at these critical points, it is essential to keep the correct radii of bends, to furnish positive support to the cables, and to assure complete watertightness at cable entrance. The cable entrance plate on the newel post is stainless steel to limit the eddy-current losses. To maintain its watertight integrity, it is gasketed tightly to the post structure. The cables pass through screwed brass stuffing tubes. Other entrance plates are provided on the opposite side of the post to facilitate installation, inspection, and maintenance of the cable.

These three ships will be put into service in the near future. The proof of completely wiring them with mineral-insulated cable will be in the actual operation of the vessels. The installation of this cable presented no serious problems, and the finished job has more than fulfilled our expectations as to space required, ease of installation, and neat appearance. It is the opinion that the installation will give many years of trouble-free service and justify a type of shipboard wiring that is new for ships built to American specifications. These installations have strengthened our belief that mineral-insulated cable will continue to have increased acceptance for general power wiring in years to come, and will go a long way toward contributing to the elimination of the presently accepted standard wiring methods on land.

Comparison of Atom-Plant Types

The nuclear physicists' language is steadily being pushed into our everyday vocabulary; for example, the atomic engine, or nuclear boiler, which started the ball fissioning, has almost as many names and descriptions as the uranium atom it splits.

Appreciating the difficulty of comparing one atomic plant with another, the nuclear engineers of Minneapolis-Honeywell Regulator Company worked out a few simplified translations. These should cover all of the reported 42 or more nuclear reactors existing in some 32 nations. The most frequently mentioned types are defined.

Power Reactors: Reactors of this type consume fissionable material for the sole purpose of generating energy. They may be stationary (power plants) or relatively lightweight (for use in submarines, aircraft). Often they are referred to as "nonregenerative" and "regenerative" reactors.

Breeder Reactor: As the name implies, a reactor literally designed to breed fissionable material and power simultaneously. It is loaded with uranium isotope U-235 and non-fissionable U-238 (or thorium Th-232). It converts the latter into usable fissionable material faster than it burns up the U-235, thus realizing the full power potential of the natural uranium. This can be a power-type reactor.

Research Reactor: Obviously a type specifically designed for scientific investigations rather than power production. Generally it is less powerful than other reactor models and consequently less expensive. It is the source of neutrons vital to research into basic physics. It too uses the uranium isotope U-235, but much less of it.

Swimming-Pool Reactor: So-called because the fuel elements are suspended in a pool of water. This serves both as a coolant and a protective shield against radiation. Generally speaking, this model is a pure research reactor.

Boiling-Water Reactor: The heat produced by splitting atoms in this reactor is used to boil water. The resulting steam is harnessed to operate a steam turbine. It is a type of power reactor.

Sodium-Cooled Reactor: One in which molten sodium is the coolant. It absorbs reactor heat and passes to a heat exchanger (boiler-like affair), where it raises steam by heating ordinary water. Also, it is a power-type reactor.

Homogeneous Reactor: Uses a liquid rather than a solid fuel; generally uranyl sulphate dissolved in water. Chief advantage is lower cost through elimination of fuel fabrication expenses. It has a uniform core material of fuel as contrasted to "heterogeneous" types in which the core is composed of different materials separated from each other. This model can be either a power or a research reactor.

Synchronous Motor Starting Performance Calculation

J. C. WHITE
MEMBER AIEE

MANY METHODS have been proposed and used during the past 50 years for calculating the starting performance of synchronous motors. Although many of these have been quite satisfactory for the bulk of design and application work, each method suffers from one of two basic faults. If the method is simple enough for routine hand calculation, much detail is lost in the solution, and the sweeping assumptions that must be made to simplify the equivalent circuits introduce considerable error. On the other hand, if the method is sufficiently detailed to eliminate these disadvantages, the numerical calculations become very ponderous.

The use of a digital computer can eliminate, to a considerable extent, the disadvantage associated with more rigorous detailed methods of starting performance calculation.

In some instances, for reasons of mechanical stress in the pole tips, it may seem advantageous to close two or more of the slots above the amortisseur bars on each pole of a synchronous motor. However, the questions which immediately arise are these:

1. How will this change affect the starting performance (torque and line current) of the motor?
2. Will differential expansion of the amortisseur bars during starting become a serious problem?

Considered here is a study of two synchronous machines which were identical in all respects save one. In Case I, the slots above the second amortisseur bars in from each pole tip were closed; in Case II, all amortisseur slots were open.

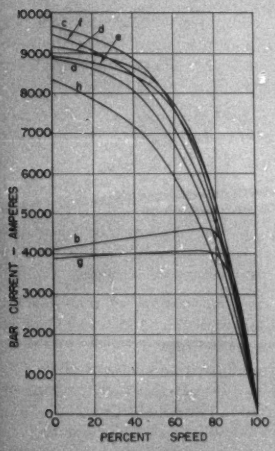

Fig. 1. Current distribution in the amortisseur bars during starting (Case I)

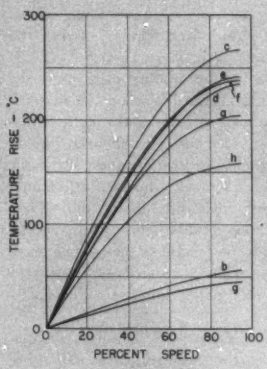

Fig. 2. Temperature distribution in the amortisseur winding during the starting period (Case II). The temperatures are expressed in terms of the rise above an assumed 25-C ambient.

In order to determine the answers to the foregoing questions, it was necessary to perform a rather detailed analysis of each motor design. The method proposed by Rankin[1] in 1945 was chosen for the analysis.

During the starting transient, the temperatures of the various bars will change radically. In order to take this thermal effect into account, an iterative solution was performed. On the initial computer run, all amortisseur bars were assumed to remain at 75 C throughout the starting transient. Then, on the basis of this initial solution, the speed–time characteristic of the machine was determined by numerical integration. Then, knowing the current distribution in the various amortisseur bars, a second set of numerical integrations yielded the bar temperatures as functions of speed. These temperatures could then be used to determine the bar resistances as functions of speed. The entire problem was then rerun, and the process was repeated until convergence occurred.

The current distribution in the amortisseur bars during starting is presented in Fig. 1 for Case I. For identification, the amortisseur bars are lettered in succession from the trailing edge of the pole. Bars *b* and *g* had closed slots above the amortisseur bars; the rest of the slots were open.

The effect of this current distribution on bar temperatures is indicated in Fig. 2. Similar curves were obtained for the motor of Case I; however, the currents and temperatures were much more evenly distributed.

REFERENCE

1. The Direct- and Quadrature-Axis Equivalent Circuits of the Synchronous Machine, **A. W. Rankin.** AIEE *Transactions*, vol. 64, 1945, pp. 861–8.

Digest of paper 56-154, recommended by the AIEE Committees on Rotating Machinery and Computing Devices and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

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Empire State Building Beacons

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The new beacons atop New York's Empire State Building, generating a total of nearly two billion candle power, will provide the world's brightest continuous source of man-made light. The features and operations of the system are described.

THE EMPIRE STATE BUILDING, for more than two decades one of New York City's greatest landmarks, has added four unique far-reaching revolving and elevating night beacons, erected 1,092 feet above the streets of Manhattan. The installations are scheduled for completion late in April. Special ceremonies will mark the official "turn-on" program.

Colonel Henry Crown, president of the Empire State Building Corporation, stated "I am hopeful that these lights will be regarded by our visitors as an air age supplement to the American welcome so long extended to ship-borne visitors by the Statue of Liberty. For us, the Empire State lights symbolize not only welcome, but also the unlimited opportunities of America and our hopes and prayers for peace."

Combined, the four beacons represent an investment of $250,000 and will generate almost two-billion candle power of light, becoming the brightest continuous source of man-made light in the world.

The complex task of engineering the beacons, designing their dual movement electronic controls, and supervising their installation on the 90th floor level is being handled by the Federal Sign and Signal Corporation of Chicago, Ill. The plan for the beacons was originally conceived by industrial designer Raymond Loewy.

Each of the beacons, which weigh over a ton apiece, will both rotate and elevate in a novel 8-phase cycle of movement. They will be installed on the four sides of the building, each on a 2,200-pound steel frame platform, at the immediate base of the multiple television tower now used as an antenna by all seven of the New York City area's television stations.

The lights will consist of four 5-foot diameter Sperry Gyroscope Company beacons, each utilizing Westinghouse Electric Corporation 2,500-watt short-arc lamps which build up temperatures as high as 1,500 F (Fig. 2). These, in conjunction with the highly polished reflector on each beacon, will generate 450-million beam candle power of light per unit. The lamps are made of quartz rather than glass, in order to withstand these extremely high temperatures. The quartz is also required to withstand the high internal pressures of the beacons. These pressures measuring over 300 pounds per square inch. Special compounds are used to seal the lenses and beacon drums, or outer shell of each beacon, to prevent moisture leakage.

Each lamp has the equivalent light output of an 11,000-watt carbon-arc lamp and has the advantage of permitting remote control operation, thus avoiding the necessity for a full-time operator. The rated average life of these lamps is approximately 200 hours. The temperature within the arc of the lamp is 8,000 to 10,000 F, which is higher than that of the sun's surface.

The four beacons used in the installation are surplus

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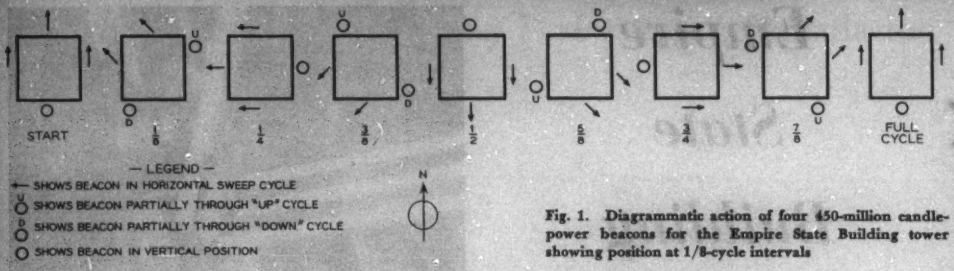

Fig. 1. Diagrammatic action of four 450-million candlepower beacons for the Empire State Building tower showing position at 1/8-cycle intervals

60-inch searchlights from World War II. The reconversion of these searchlights consisted of two separate projects: the installation of the *2500-SAH* mercury lamps by the Westinghouse Electric Corporation and the adaptation of the searchlight to fit the control scheme used in the installation. The searchlight was stripped of all original drive and control components, taken apart, and new support bearings installed at the Chicago plant of the Federal Sign and Signal Corporation.

The motors selected are of the $^1/_2$-horsepower, 208-volt, 3-phase, synchronous squirrel-cage type, with integral reduction gears and motor brake. Since the searchlight display must exhibit parallel beams for appearance, the synchronous type motor was chosen with integral brake for precise stopping.

Fig. 2. Model holds tiny bulb which provides light power for one of the four giant beacons at the 90th floor level of the Empire State Building.

Two motors per searchlight are used. The elevation motor drives the drum between horizontal and vertical, and the azimuth motor drives the searchlight counterclockwise at one revolution per minute about a vertical axis.

The searchlights are aligned horizontally and kept in synchronization by the sequential operation of two limit switches per light. The control circuits were designed to give maximum flexibility. Each searchlight can be individually controlled from its site and any light can be stopped for servicing without disturbing the synchronization of the others.

The controls, grouped on the 90th floor of the building, consist of a power distribution panel (supplying 3-phase, 208 volts and single-phase, 120 volts through thermal-trip circuit breakers) and three cabinets containing time clocks, contactors, relays, and terminal strips. A total of two time clocks, one time delay relay, 12 contactors, and seven auxiliary relays are used to control the beacons.

ROTATION PATTERN

THE BEACONS will revolve in perfect synchronization in a horizontal plane at one revolution per minute counterclockwise approximately 180 degrees in a horizontal plane; then, as they turn to the building, they will be elevated individually to sweep vertically up across the television tower one side at a time, exposing the tower to a bright path of light. The beacon operation is shown in Fig. 1.

The "at rest" position of the beacons, or the position from which they will be turned on, has the north, east, and west beacons all pointing north in the horizontal plane and all three parallel with each other. At this precise instant the south beacon is pointing directly up the south side of the tower. Following this, the next quarter-cycle has the north beacon moving horizontally to the west, the west beacon continuing its horizontal movement westerly, and the east beacon starting its upward cycle, while the south beacon begins its downward cycle to the west.

At the second one-quarter revolution stage the north, west, and south beacons are pointing horizontally west, and the east beacon points vertically up the tower. The cycles repeat for each side of the building so that three beacons point horizontally, and the fourth vertically at all four directions.

SYNCHRONIZATION

OPERATION OF THE BEACONS will always be synchronous, and all movements will be completely automatic. A special built-in feature for the operating controls of the Empire State lights provides that if any one of the beacons should go out of synchronization for any reason, all of the beacons will automatically be returned to synchronous operation before the next revolution takes place. At the end of each night's operation, the beacons will all point north so that during the following day the sun will not reflect off the beacon mirrors. The beams will be focused slightly above the horizon. Hours tentatively set for operation of the lights are from sundown to midnight.

A torque-limitation clutch between the drive motor and the revolving mechanism has been engineered into the equipment so that if high winds of a velocity sufficiently strong to damage the operating mechanism should hit the face of the beacons, the clutch will take up the force of the wind rather than permitting the wind to cause mechanical damage. The beacons and the platforms on which they rest are designed to withstand wind velocities up to 120 miles per hour.

Each of the beacons is mounted on structural steel framework rigidly connected to the beams of the building. The steel framework provides platforms for service and maintenance of the lights. A shield over the top of the beacons prevents damage from falling ice from the television antennas on top of the tower.

ELECTRICAL INSTALLATIONS

THE ELECTRICAL INSTALLATIONS were made by L. K. Comstock and Company, New York, N. Y. First a feeder was tapped on the existing panel inside the building at the approximate level of the beacons with four No. *2/0* cables. These cables were extended through a $2^1/_2$-inch conduit nipple to a location adjacent to the existing panel where a new 200-ampere fused disconnect switch was installed. The conduit containing the cables was then installed downward through a concrete slab to a lower exterior level, where a 200-ampere, unfused rain-tight switch was installed. In this exterior, but protected, location were mounted the beacon control cabinet, contact cabinet, and distribution panel.

From the control center, two $1^1/_4$-inch conduits were run to each beacon location, one containing two No. *4* wires for the power supply, and the other containing 16 No. *14* wires for the control wiring.

The materials supplied and installed were the standard materials for outdoor use. There were no outstanding difficulties in setting up the installation other than adverse weather conditions.

ESTIMATED RANGE

ONE INTERESTING FEATURE concerning the new beacons is the distances from which these lights will be seen. On the ground on ideal nights, Federal Sign and Signal engineers estimate that the beams of light from the Empire State Building could be seen by persons on Long Island approximately halfway between Sayville and Southampton; in Connecticut, approximately as far as Bridgeport; in New York State, as far as Poughkeepsie; and in Pennsylvania, as far as Allentown and Bethlehem. These locations roughly describe an 80-mile arc from the installation. Under absolutely optimum conditions, it is conceivable that the lights could be seen from Philadelphia, 95 miles from New York's Fifth Avenue and 34th Street.

Helicopter Used in Swiss Hydroelectric Project

One Bell Aircraft Corporation helicopter, serving as an Alpine airlift, delivered in record time all the men and equipment required to establish a construction camp nearly 7,000 feet up in the Swiss Alps. In less than 100 flight hours the busy model *47G* helicopter picked up 206 men and 120 metric tons of materials and equipment from the loading site at Linthal (2,135 feet) and delivered them to a relatively inaccessible spot called Limmernboden at 6,565 feet altitude. Among the items transported by the Heliswiss craft on several of its 480 round-trip flights were unwieldy prefabricated housing sections which were assembled at the camp site into combination offices and bunkhouses.

By using the 200-horsepower helicopter, the work preliminary to actual construction of a huge hydroelectric power project is proceeding far ahead of schedule. Time is the most valuable commodity in the Alps, where heavy snowfall stops all operations for at least six months out of every year.

Photographer Hans Burgunder of Berne, Switzerland, who made the accompanying picture, reports that it takes an experienced mountain climber, traveling light, seven hours to make the same trip the helicopter completes in approximately 20 minutes.

The Residential Primary Service Unit System

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PERHAPS the most widely discussed distribution problem arises from the necessity of transporting energy considerable distances at low voltage. With increased load densities, it is necessary to use large secondary conductors to keep voltage variations and power loss within acceptable bounds, and supplementary means of voltage control are often needed. Even then, it is sometimes impossible to utilize the full thermal capability of distribution transformers because of voltage problems.

Another problem of increasing importance arises in supplying relatively large motors, as used in heat pumps or central air conditioners, at 120/240 volts. At present, there is limited use of separate 3-phase or higher voltage single-phase services to supply such loads, but these have not been adopted generally because of the added cost which they entail. Some consideration has been given to the employment of the higher residential voltages which are common in many foreign countries. Such a change, however, presents problems of safety and of appliance interchangeability.

Conventional systems are vulnerable to damage or outage caused by external agencies, by virtue of their exposure to lightning, wind, sleet, traffic, birds, trees, and falling objects.

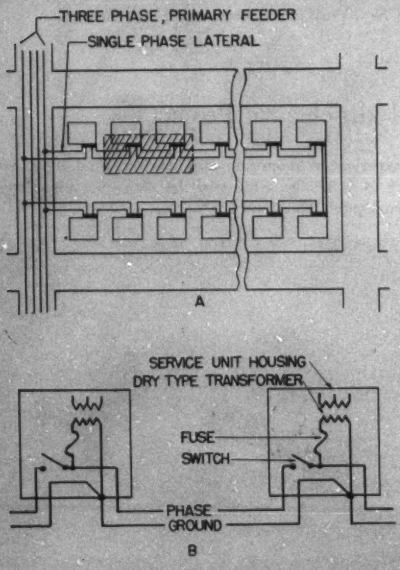

Fig. 1. Details of primary circuit: (A) typical single blocks (B) detail of shaded area in (A)

Even more serious is the wholesale destruction of plant, with attendant long-duration outages, resulting from the increased incidence of hurricanes and tornadoes in several areas.

The primary service unit system was devised as a possible solution to these and other problems encountered in residential distribution. Basically, it embodies the following features:

1. Energy is supplied to the consumer's premises at primary voltage.
2. Dry-type transformers, mounted above grade at the consumer's premises, permit the selection of suitable utilization voltages by means of series-parallel connections of the secondary windings.
3. The transformer and associated equipment are assembled into a suitable "package," which will be designated here as the "primary service unit."

As shown in Fig. 1, 3-phase feeders supply single-phase, looped laterals, sectionalized by a switch and protected by a fuse at each service. The transformers supply 120/240 volts for lighting and small appliances, and can also supply 480 volts where it may be desirable for major loads. The service unit, containing the transformer, meter, switch, and fuse, may be affixed to the exterior wall of the dwelling or recessed into the building wall or foundation.

Comparison of the proposed underground system with a conventional overhead system indicates that the initial cost of the former would be higher, but that operating costs may be more favorable to the latter. To complete the comparison, values should be assigned to the advantages of the proposed system: elimination of low-voltage secondaries and services, inexpensive provision of a higher utilization voltage, invulnerability to damage by external agencies, and improved flexibility of operation. On the other hand, some probable disadvantages should also be considered, including increased total distribution transformer rating, increased cost per kva of distribution transformers, reduced accessibility of primary circuits, and the need for independent street-lighting structures.

The primary service unit system was devised as a possible solution to the growing problems of residential distribution. It probably will require a higher initial investment than a conventional system, but this may well be justified by operating economy and other advantages. These considerations indicate that this proposed system merits serious consideration as a means of supplying the distribution loads of the future.

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Protection of Bus Duct with Current-Limiting Fuses

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METHODS FOR PROVIDING the best possible short-circuit protection of busway systems continue to be of prime importance to users and manufacturers of this equipment. The importance of preventing fault-current damage to the busway system arises from the necessity of protecting plant personnel, the high replacement cost of the equipment itself, and the financial and productive losses occurring through the forced inactivity of large sections of the industrial plant. The current-limiting fuse has been investigated and found that it contributes significantly to the improvement of short-circuit protection of busways and associated equipment.

Busway systems for low-voltage applications consist basically of two types of duct: feeder duct for transmission of power to distribution centers; and plug-in duct for distribution to individual loads and smaller load centers. The bus bars of feeder duct are insulated, placed in close proximity for reduction of transmission losses, and usually enclosed in a ventilated housing. Plug-in duct bars are usually uninsulated and placed in a totally enclosed steel casing with openings at selected points for the insertion of power tap-off devices. Both types of duct can be subjected to bolted short circuits, with feeder duct generally encountering higher currents because of its lower impedance and closer proximity, usually, to the source of power. The uninsulated character of plug-in duct, however, makes it more susceptible to arcing faults within the structure.

Present-day protective systems for bus duct usually employ either circuit breakers or switch-fuse combinations to provide disconnecting and protective means, their choice depending on available fault currents and nominal ratings. Circuit breakers are sometimes preferred regardless of circuit requirements, because of the convenience in immediately reclosing the circuit after tripping on overloads and the minimum fault interruption time for current values above the selected overload range.

The degree to which present protective methods prevent short-circuit damage to busway systems can be considered to be adequate for bolted fault conditions, where the protective device and duct have been properly applied within their short-circuit ratings. Other factors, however, such as higher and higher short-circuit currents from increasing available power, the improvements required in existing installations from past misapplication or disregard of adequate short-circuit ratings, and arcing faults, in general, point up areas where present protective methods may be inadequate or impractical to employ.

Employing high interrupting capacity protective devices in new installations or substituting proper devices in existing installations to clear satisfactorily the expected fault currents does not necessarily protect bus duct since, in the case of a breaker, the full increased fault current is still permitted to flow. The use of duct having proper short-circuit ratings or the replacement of duct in existing installations is often neglected because it would be impractical or costly.

Fig. 1. Comparison of bus bar distortion from 3-phase bolted fault tests. Duct on right protected by circuit breaker. Duct on left protected by current limiting fuses

The difficulty in providing protection from arcing faults by means of a circuit breaker lies in the fact that the breaker has a minimum response time above its overload range. Hence, burning damage increases with increasing fault current. An arcing fault can do considerable damage in 1 to 2 cycles at 20,000 to 30,000 amperes.

The increase in short-circuit protection, provided by current-limiting fuses in combination with circuit breakers, has been determined by tests conducted with bolted and arcing faults. The results indicate that the bolted fault protection of bus duct can be considerably extended beyond its short-circuit rating by the application of a current-limiting fuse, which begins to limit current at or below the short-circuit rating of the duct. Fig. 1 shows the results of one of the tests conducted on plug-in ducts employing 1/4- by 1-inch copper bars.

Results from the arcing tests were equally as effective in showing the minimized burning damage from the use of current-limiting fuses. Since no rating can be assigned to any piece of equipment for resistance to burning damage, the general conclusion indicates that the lowest rating of current-limiting fuse should be employed consistent with the overload requirements of the circuit. When employed with circuit breakers, maximum over-all protection against arcing faults is obtained.

In the application of current-limiting fuse-breaker combinations, it has been found that the use of a low fuse size may permit a decrease in the required interrupting capacity of the breaker. Hence, economy is introduced which is accompanied by greater safety to the duct systems.

Digest of paper 56-46, "Short-Circuit Protection of Busway Systems with Current-Limiting Fuses," recommended by the AIEE Committee on Switchgear and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956. Scheduled for publication in the AIEE *Power Apparatus and Systems*, 1956.

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Liquid Cooling of Turbine-Generator Armature Windings

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An account of the development of liquid cooling for turbine-generator armature windings is presented. Included is the solution of various detail problems which have arisen in the course of perfecting the new cooling method.

LIQUID COOLING has recently been developed as a method for providing a suitable means for the removal of heat from the armature windings of turbine-generators. The heat generated by losses in the armature conductors is removed from the winding by the flow of liquid either through passages in the conductors themselves, or through auxiliary passages built into the winding.

The need for this, or some similar development, is apparent when one considers the tremendous growth of American power systems and their pressing needs for ever larger generating units. By 1950 it became very clear to the designers of these machines that within the next few years another such improvement would become necessary, and further, that it would be most desirable that this development be capable of application to generators approximating 500,000 kva.

Many possible improvements in cooling were studied, and two of them (one method using liquid and another using gas) have been perfected and are now being applied. Of the two methods, liquid cooling offers greater opportunities for expansion in the kva size of the units while simultaneously retaining design flexibility to meet operating characteristics and maintaining the high level of operating efficiency established by existing machines. For these reasons much effort has been directed towards its perfection.

The first turbine generator, Fig. 1, a 260,000-kva, 3,600-rpm, 18,000-volt machine, with liquid-cooled armature windings was completed and tested in 1955 and is to be placed in operation at the East Lake Station of the Cleveland Electric Illuminating Company in 1956. This generator is built with a one-piece stator frame in which the armature core and windings are completely factory assembled for single-unit shipment. Four hydrogen coolers are mounted horizontally transverse to the machine axis in a large dome placed on top of the frame in final assembly at the power plant. These coolers, which can be seen in Fig. 1, remove heat from the hydrogen gas which is circulated through the armature core and the rotor in a normal manner by conventional axial flow fans. The rotor employs the gap-pickup type of cooling described in AIEE papers.[1,2]

Fig. 1. The first turbine-generator with liquid-cooled armature windings set up for factory test. Rated 260,000-kva, 3,600-rpm, 18,000 volts, it is for the Cleveland Electric Illuminating Company, East Lake Station.

FLUIDS AND FLUID PASSAGES FOR LIQUID COOLING

THE HISTORICAL METHODS of improving armature cooling by the shift from air to hydrogen as a cooling medium and by increasing the mass flow of the hydrogen by raising the casing pressure have been based on the removal of copper losses by heat flow through the main electrical ground insulation. The copper losses are dissipated to the cooling medium from surfaces provided by passages in the magnetic iron of the core. As these surfaces are located radially outside of the armature slots, only minor problems of effective utilization of material and space in the area of the slots and the teeth on the armature core were encountered. The ring of material in this region, between the gap surface of the stator punchings and outer diameter of the slots, and the two ends of the core largely determine the efficient performance and the output of the armature. In conventionally cooled machines, this space contains the copper which conducts the current; iron which carries flux and, hence, enables voltage production; and insulation. Two parts of this space contribute to the production of kva; one, the insulation, does not. In machines with conductor-cooled

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armature windings, a fourth function, cooling, is crowded into this space, and space must be taken from the working elements, copper and iron, to admit the newcomer. Consequently, it is of basic importance that this space be as small as possible and that the coolant chosen be capable of absorbing the greatest amount of heat per degree rise in temperature for a given cross section of cooling passages.

Table I compares the relative rates of heat removal by a number of fluids under the same conditions of temperature rise and duct area with velocities of flow that are practical for employment in turbine-generators (gas velocities are about 80 to 90 times that of liquid). It is obvious from this table that liquids as a class are outstanding in this respect, and also that for equal heat removing capacity, liquids will require substantially smaller passages.

Fig. 2 shows a schematic diagram of one of a number of possible arrangements of the liquid flow circuits for an armature winding. Fig. 3 shows cross sections of two types of bar construction which have been developed to provide the passages inside the ground insulation surrounding the conductors. The hollow-strand type of bar, which has been used in the East Lake machine, makes the most effective use of cooling area and brings the coolant into the most intimate contact with the conductors, thus making possible the most compact and efficient winding design. However, for certain sizes and voltages of generators, the strand dimensions of the hollow strands become too large for minimum eddy-current losses, or if the number of strands is varied, they may have unfavorable proportions for optimum design and, hence, the hollow-tube type of bar may be more suitable under these conditions. It does not utilize the space as effectively as the hollow strand types, because of the space needed by the tube walls and the necessity to insulate the tube walls from the strands. It also is less effective in heat removal because of the thermal drop through the strand and tube insulation, and through the tube wall between the copper and the coolant.

In addition to good thermal properties, a cooling liquid must have, and maintain, high dielectric properties. It must be chemically and thermally stable, and should not form substances which would damage other parts of the machine under any foreseeable conditions which might arise in the generator. Liquids having a minimum fire hazard, low maintenance cost, and ready availability are preferred. Consideration must also be given to low freezing temperatures (for outdoor stations), and reasonable boiling temperatures. To arrive at a suitable liquid, many materials have been thoroughly considered, among them

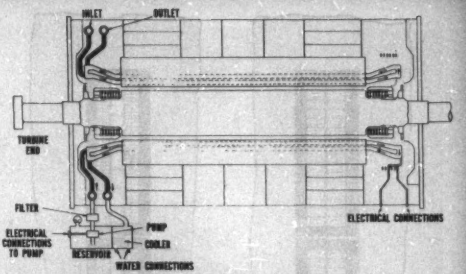

Fig. 2. Schematic drawing showing liquid-flow circuits for liquid-cooled armature winding

being Transil oil, Pyranol, silicone, oil water, phosphate esters, carbonate esters, and a number of polyethylene glycols. Each of these liquids has advantages and disadvantages, and for the first application, Transil oil has been chosen because of its high dielectric strength, good cooling properties, chemical inertness to insulation, and its historically long use in electrical apparatus, with considerable data available on its performance.

ARMATURE WINDING AND ITS LIQUID CONNECTIONS

Armature Bar Strands. The stator bar as shown on the left in Fig. 3 is composed of a number of strands transposed in the conventional Roebel arrangement, but using rectangular copper tubing for the conductors. The coolant flows through all strands of the bar in parallel. This type of cooling circuit within the armature bar requires that the tubing end connections be leakproof, and that in the event of an accident, liquid leaking from the strands must have no damaging effect on the main ground insulation system.

When the insulated strands are transposed and assembled to form an armature bar, they must be successfully terminated at each end of the bar so that the current can be collected and the cooling liquid can be introduced or discharged in a reliable, leakproof manner.

Strand Termination. The strand termination, or hydraulic clip is a hermetically sealed, permanently brazed joint which becomes an integral part of the bar. Hollow strands are permanently joined to the hydraulic clip and solid strands of copper conduct the current away from the bar. A hydraulic fitting accommodates the cooling fluid.

Fig. 4 shows the uninsulated bar arrangement at the turbine end of the generator, indicating both the electrical and hydraulic connections. Later the compounded armature bar ground insulation will cover the hydraulic clip, thus providing space for overlapping the tape which insulates the series loop connections. This arrangement allows for adequate electrical creepage in the end windings. The use of the high-temperature brazed joint in the strand termination permits the electrical connection to be made in

Table I

Fluid	Relative Specific Heat	Relative Density	Relative Practical Volume Flow	Approximate Relative Heat-Removal Ability
Air	1.0	1.0	1.0	1.0
Helium, 1/2 pound	5.25	0.138	1.0	0.75
Hydrogen, 30 pounds	14.35	0.21	1.0	3.0
Hydrogen, 45 pounds	14.35	0.28	1.0	4.0
Transil Oil	2.09	848.0	0.012	21.0
Pyranol	1.09	1510.0	0.012	20.0
Water	4.16	1000.0	0.012	50.0

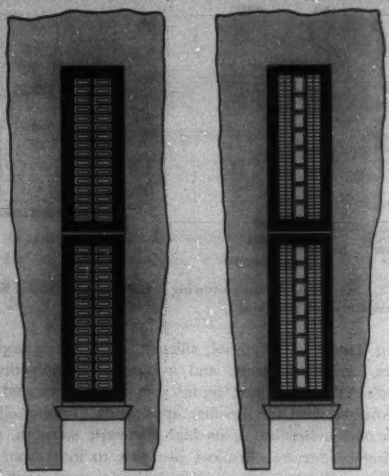

Fig. 3. Two types of armature bar construction. On the left is shown the transposed tubular strand construction; on the right, the arrangement of central ducts for coolant flow

the conventional manner. Here solid strands are used for flexibility in assembly and joined by means of an external copper clip mechanically tightened by the use of opposing internal wedges. The strand clip and wedge assembly is then filled with solder to insure low electrical contact resistance. The stainless steel tubing which carries the liquid coolant is then assembled to the fittings shown in the figure. An alternative design uses brazed connections in place of fittings for all metallic joints. Tests have shown the two constructions to be quite comparable in liquid tightness. The completely assembled joint is then insulated in the manner normally used to insulate series connections.

It is apparent that the design just described provides armature bars which can be assembled in the stator slots using the same techniques and methods employed for many years, the only difference being the addition of the hydraulic elements. These are remarkably simple.

The collector end of the completed armature winding has the appearance of a conventional winding as the liquid paths are contained inside the end loop insulation.

Liquid Connections. The turbine end of the East Lake winding indicates a departure from the appearance of a conventional winding, for it is at this end that the armature bars are connected hydraulically to the inlet and outlet liquid headers. The three principal requirements of these liquid connections from the headers to the winding are the provision of electrical insulation, mechanical flexibility, and long, reliable life. This problem has been solved in two ways.

One method as used on the East Lake generator separates the electrical and mechanical requirements. This arrangement is shown in Fig. 5, and includes a two-pass rigid electrical insulator in series with flexible stainless steel connections which provide the required mechanical isolation. This design assures the reliability and long life required for turbine generator operation.

The second approach to the hydraulic connections has been to simplify the arrangement by combining both the electrical and mechanical functions in one liquid connector. A material has been found which will satisfy these requirements while simultaneously providing the reliability necessary to this design, as shown in Fig. 8.

To select the best possible connector from the many materials available, and to obtain the most durable end fittings, a special test setup was devised. Fig. 7 shows this test setup consisting of a hydrogen tank in which is placed a mounting rack where several of the connectors can be seen. The rack assembly provided a means of subjecting the liquid connectors simultaneously to severe conditions of vibration, displacement, voltage, ambient temperature, fluid flow, and pressure, all in a hydrogen atmosphere. As can be seen in this illustration, the rack contains a number of magnetic vibrators which oscillate the connectors at 120 cycles per second, a device for providing displacement of the ends of the connectors with respect to each other, insulators, and fluid connections to an outside fluid-circulating system.

During the last 15 months, some 11 different connector materials with many variations in end fittings have been tested under accelerated aging conditions. Typical conditions consisted of applying 40 times normal amplitude of 120-cycle vibration, many displacement cycles, three times normal voltage stress, and twice normal ambient temperature while simultaneously flowing Transil oil through the connectors at twice normal pressure and at elevated temperature. From this comprehensive program, only those connectors which have proved their ability to withstand simultaneously all of these conditions have been accepted. The presently accepted materials have withstood the full time of this entire test, and so far are in perfect condition. The test will continue until the successful connectors show evidence of weaknesses until the test equipment itself fails first.

Tests on the Armature Winding. A fundamental consideration for the complete winding concerns the equality of liquid flow through the individual tubular strands of the armature bars. This was demonstrated by a full size flow test setup in the laboratory.

The setup consists of a pair of circular inlet and outlet headers about 9 feet in diameter, each with transparent observation windows at four 90-degree points. A full-sized armature coil, which consists of two bars, each with Roebel transposed tubular strands, is mounted on a support ring that places one coil end in the proper physical relationship with respect to the ring headers. The other end of the coil was supported on a similar ring header. These ring supports permitted the coil to be rotated so that the one test coil could, in sequence, occupy every coil position in an armature around the full 360 degrees of the gap circle. Thus, by altering the angular position of the coil, the liquid

flow through the bar could be appraised in every position.

The bars themselves were made of tubular copper strands as were those used in the machine, except that two of the strands on each bar were replaced with transparent plastic tubing of equal cross section. All strands at each end of the bar terminated in a hydraulic clip similar to that used in the generator, except that, in this case, the clips were made of a transparent plastic. The use of plastic windows in the headers, liquid connections, plastic strands, and plastic clips, permitted visual observation of the internal working of the complete fluid circuit. This was supplemented by the usual methods for measuring flow and pressure distribution throughout the circuit. Using Transil oil, and varying the flow from practically zero to the maximum flow expected in the coil during generator operation, it was conclusively demonstrated that all strands would be filled with the fluid at all coil positions. To determine the effect of entrained gas pockets, large quantities of gas were introduced into the system at various angular positions of the coil. In all cases it was observed that the oil flow purged the gas from all pockets, immediately carrying it out of the liquid circuit. This setup was made with the pump circulating the fluid at atmospheric pressure, and the air used in the test was removed without the aid of a vacuum in the liquid reservoir. Addition of vacuum conditions, as those used with the generator itself would make the action described even more positive.

The necessity for maintaining the proper areas and conditions within the completed winding circuit for proper liquid flow is evident. Special techniques in the manufacturing cycle were employed to maintain these conditions and to assure the quality of the generator winding. These techniques were used in addition to the standard precautions, tests, and inspections used for a conventional generator. Two types of special tests were used, the first being tests to insure that all stator bars were leak-tight. After the bars are formed and the end hydraulic clips are assembled and brazed, a static gas pressure of 80 psig (pounds per square inch, gauge) is applied to each bar to reveal any structural weakness in the joints. The entire bar from end to end is then subjected to a leak test with a helium mass spectrometer. In this extremely sensitive test, the inside channels of the bar are evacuated; the discharge from the vacuum pump being metered by the mass spectrometer. The complete outside surface of the bar is hooded, the hood being filled with helium. The slightest leak of helium into the evacuated bar then is detected by the mass spectrometer. The sensitivity of this instrument is such that with proper test conditions, and under one atmosphere of pressure, leakage of helium at the rate of 0.002 cubic inch per year can be detected. All bars must pass mass spectrometer leak test before ground insulation is applied.

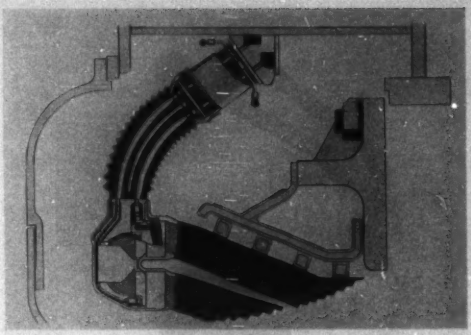

Fig. 5. Arrangement for making liquid connections between the armature coils and the liquid header; located at turbine end of generator

Fig. 4. Arrangement of uninsulated armature coil series connection showing method of making electrical and hydraulic connections

Likewise, all other components which carry the liquid coolant must pass the mass spectrometer leak test before and after assembly in the generator frame. These components include the flexible hoses, the insulators, oil headers and piping, armature connection rings, and the stainless steel tubing. All hydraulic fittings are tested in this manner before the electrical insulation is applied.

The second basic type of production testing performed is the flow test, which consists of a series of tests on each bar that is designed to insure that proper fluid flow areas within the bar are maintained throughout factory handling and processing. In this sequence of tests, the flow of air through the bar with a given pressure drop is measured. This test is made several times throughout the bar manufacturing cycle, and a test history is kept on each individual bar so that any change can be noted. The final flow test

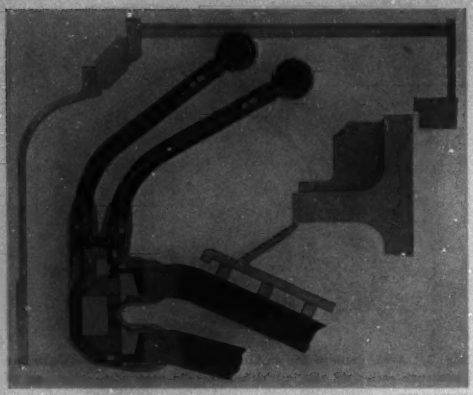

Fig. 6. Alternative method for making liquid connections between the armature coils and the liquid header

is made on each bar after its assembly when it is in its final position in the armature.

OPERATION

GENERATORS with liquid-cooled armature windings may be operated in practically the same manner established by the successful operation of more conventional machines. The liquid cooling system cools the winding automatically, and the generator output may be increased or decreased at the desire of the operator, in order to be consistent with good practice with respect to the turbine and the boiler.

For comparison with conventionally cooled winding temperatures at their usual indicating positions, the first liquid-cooled winding has resistance temperature detectors located in the customary slot portion of the winding between the bars. However, these detectors will not reflect accurately the liquid-cooled winding's significant temperatures because most of the heat generated in the copper is removed internally by the liquid, and does not flow through the insulation to the vicinity of the resistance temperature detectors. Also, in addition to this fact, the highest copper temperature in a liquid-cooled winding is not within the slot as is the case of a conventional winding, but is near the bar end where the liquid emerges from the winding. Therefore, in the first generator, 12 permanent thermocouples have been located to read the liquid temperature of these individual coils adjacent to their discharge point into the outlet header. It is expected that these thermocouples will read within a few degrees of the highest copper temperature. In addition, thermocouples in the inlet header will indicate the cool liquid temperature. Fig. 8 shows the temperature distribution characteristic for such windings, indicating the need for temperature readings at the chosen locations.

The liquid circulating equipment has been arranged with reliability and continuity of operation as a primary objective. Similar to, but independent of the hydrogen-seal oil system for the generator, main and emergency pumping equipment is provided with automatic throw-over features and is equal in reliability to that of the hydrogen-seal system and the essential bearing-lubricating system. However, as an additional protection against damage to the generator in the extremely improbable case of a failure of the main and all backup liquid circulating pumps, an alarm can be sounded and a pressure switch provided which can be arranged to actuate the closing of the turbine control valves so that the load is brought to a safe level for operation of the generator armature without circulation of the cooling liquid liquid. Even such operation can produce substantial kva. In the case of the first liquid-cooled generator, approximately one half of rated kva can be carried at 30 pounds hydrogen casing pressure without flow of liquid through the armature windings.

The precautions taken to provide a tight liquid circuit in the generator have been described. However, to be doubly sure that the operation of the generator will not be jeopardized in the remote possibility of a leak in the main circulating system, the first liquid-cooled armature winding

Fig. 7. Test arrangement for life testing connections for liquid-cooled armature windings

machine incorporates a special continuously operating system for preventing such liquid leakage into the body of the machine and, at the same time, to detect any opening that might develop in the liquid circuit. This arrangement is incorporated in the external liquid system by providing for the maintenance of a vacuum on the liquid discharge headers within the generator. The liquid pressure is automatically adjusted so that at the highest pressure point in the internal liquid system (the inlet header), the pressure is maintained at 3 psig less than the hydrogen casing pressure. Therefore, any leak of small or moderate size would be that of hydrogen into the liquid system, and except for a major rupture of the hydraulic system, no liquid coolant would discharge into the generator atmosphere. The device for keeping the liquid pressure lower than the casing pressure permits monitoring of any discharge of gas and vapor from the vacuum pump. Should a leak occur, a low-vacuum alarm would sound, the amount of gas leakage could be measured on a flow meter, and by means of checking a purity gauge for the presence of air or hydrogen, it can be determined quickly whether such a leak is inside the generator or in the external piping. This leak-detection system does not affect the operation of the generator with respect to the ambient casing pressure, since any variation in the hydrogen pressure is compensated for automatically, and the differential pressure between liquid and hydrogen is maintained automatically.

It is believed, that whereas the first system to incorporate these features includes the necessary provision to check the machine continuously, very likely continuous checking will be unnecessary. When this is established, an alternative system somewhat simpler in its arrangement can provide all of the features of the first system with periodic rather than continuous checking.

CONCLUSIONS

Liquid cooling is a practical and effective tool to increase the outputs attainable from turbine-generator armature windings. The liquid coolant system, now perfected, can be applied readily to all sizes and types of large machines without involving complex design proportioning to accommodate the cooling system. Basically, this is so because the cooling ability provided by the liquid cooled approach establishes a thermal limit for the armature winding much higher than other design limitations in the completed machine. Consequently, with liquid cooling thermal design of the armature, winding is no longer a limiting factor. The circulating system is extremely simple and very reliable. This step parallels, in many respects, the step to hydrogen cooling made some 20 years ago when a more effective heat-absorbing fluid than the air previously used was introduced into the machine.

The thermal limit of liquid-cooled windings easily permits the design of armatures for 500,000-kva rating in 3,600-rpm machines, and undoubtedly larger capacities are possible. However, other limitations in the complete machine design are likely to be lower than this figure. Nevertheless, today 3,600-rpm generators are available in capacities of 400,000 kva or more at 30-psig hydrogen pressures. Such ratings are practical within the weight and

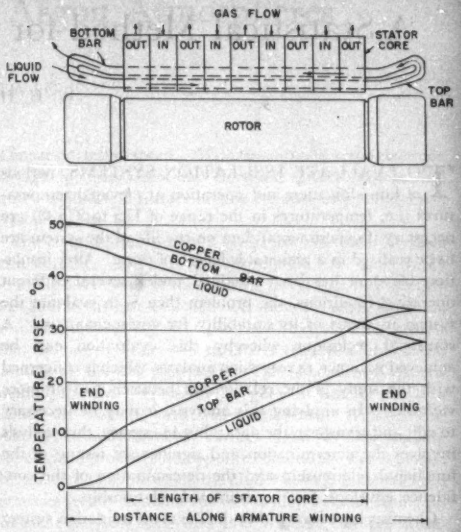

Fig. 8. Calculated temperature distribution curve for liquid-cooled armature winding with two-pass coolant flow

dimension limitations set by American rail transportation and the mechanical limitations of stress and critical speed established by the rotor diameter and length. Even larger kva 1,800-rpm generators are practical, and the combination of two such generators in a cross-compound turbine-generator unit brings into focus a very real possibility of generators feasible for a 1-million-kva unit.

Today over 2-million kva of large 3,600-rpm generators, ranging in capacity from 200,000 kva upwards, and having liquid-cooled armature windings, are under construction. These are the forerunners of many similar generators in the future.

REFERENCES

1. Direct Cooling of Turbine-Generator Field Windings, **H. D. Taylor, C. H. Holley.** AIEE *Transactions*, vol. 73, pt. III-A, January 1954, pp. 542–7.

2. Gap Pickup Conductor Cooling of Turbine-Generator Fields. Ventilation Arrangements and Analysis of Performance, **D. M. Willyoung.** Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

3. Supercharged Hydrogen Cooling of Generators, **Sterling Beckwith.** AIEE *Transactions*, vol. 71, pt. III, January 1952, pp. 168–175.

4. Improved Cooling of Turbine-Generator Windings, **R. A. Baudry, P. R. Heller, H. K. Reamey, Jr.** *Ibid.*, pp. 214–220.

5. Progress in the Design and Application of Large Steam Turbine-Driven Generators, **C. E. Kilbourne, J. B. McClure.** *Proceedings*, American Power Conference, Illinois Institute of Technology, 15th Annual Meeting, Chicago, Ill., vol. 15, 1953, pp. 358–74.

6. Inner-Cooled Turbine Generators, **J. W. Batchelor.** *Ibid.*, pp. 375–8.

7. Present Status of Supercharged Cooling, **W. L. Ringland, L. T. Rosenberg.** *Ibid.*, pp. 379–84.

8. Stray Losses in the Armature End Iron of Large Turbine Generators, **R. L. Winchester.** AIEE *Power Apparatus and Systems*, June 1955, pp. 381–91.

9. Direct Cooling of Alternator Conductors, **Diedrich Harms.** *Engineering Digest*, April 1955, pp. 37–44.

10. The Design and Performance of Modern Large Turbine Generators, **B. M. Cain, Dean Harrington.** Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

A Statistical Method for Predicting Insulation Life

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TO EVALUATE INSULATION SYSTEMS, periods of humidification and operation at elevated temperatures (i.e, temperatures in the range of 175 to 275 C) are necessary if experimental data on the life of the system are to be realized in a reasonable length of time. After insulation life data has been obtained under several different operating conditions, the problem then is to evaluate the system in terms of its suitability for commercial use. A statistical technique whereby this evaluation can be achieved is known as regression analysis, which is concerned with the study of the relationship between two or more variables. In applying this analysis, it may be necessary to edit and transform the data; but in essence, this analysis involves the determination and significance testing of the functional relationship and the determination of the confidence envelope for the estimated relationship.

Chemists have shown that the life of an insulation system is related to the deterioration rate and, thus, is dependent to a great extent upon temperature in the following manner:

$$\text{Life} \sim \frac{1}{\text{Reaction Rate}} = Ae^{B/T}$$

where A and B are constants and T is the absolute temperature. By taking logarithms, this equation can be expressed as a simple linear function:

$$Y = a + bX$$

where Y is logarithmic insulation life, a and b are constants, and X is the reciprocal of the absolute temperature.

The first step in the regression analysis would be to make a rough plot of the experimental data, using a logarithmic scale for insulation life and a reciprocal scale for the absolute temperature. If the data appear to be linearly related by this plot, the next step would be to determine values of a (the intercept) and b (the slope) which will give the best straight line. "Best" is defined as that line which makes the sum of squares of the deviations of the observed Y's from the estimated Y's a minimum.

However, before actually determining a and b, a test for the significance of the apparently linear relationship is made. This test can be made by computing the correlation coefficient r for the transformed life-temperature data and comparing this computed value with those in standard tables. If the computed value is greater than that given in the table for some level of significance, then the relationship can be said to be significant at that level.

The quantity r^2 can be used as a measure of the efficiency of the estimated equation in that this value would give the percentage of the sum of squares of the deviations in the observed Y's that is accounted for by the regression line. If the relationship is found to be a significant one (as denoted by the values for r and r^2), the coefficients a and b are estimated. Because these two values are estimates, the possible error in the functional relationship between life and temperature must be considered.

The standard error of the regression line is obtained, and the confidence envelope for the line is computed. Since the intercept a, as well as the slope b, are subject to possible error in estimating the best line, the confidence envelope is seen to expand in both directions from the mean test temperature. This implies that the estimated line may be in error not only in a parallel direction but also in a rotational direction about the mean test condition.

In the use of the regression technique, it is well to be cognizant of some necessary assumptions that must be fulfilled. In general, the designation of the dependent and independent variables (Y and X, respectively) is from a suspected cause-and-effect relationship, with the independent variable as the cause and the dependent variable as the effect. It is not always necessary that such a situation exist; however, in such cases the interpretation of the results of the analysis must be made with caution.

The variation in, or the variance of, the dependent variable must be homogeneous for different values of the independent variable. For insulation life data, the logarithmic transformation in general satisfies this requirement.

If the confidence envelope is to be used, not only must the variation in the dependent variable be homogeneous for different values of the independent variable, but this variation must be assumed to be distributed normally or approximately so. Again, a transformation may alleviate any difficulty that may be encountered.

A very important aspect to be considered in the application of the regression or any statistical technique is the means by which the experimental data were obtained. Such should always be obtained in a random manner, in order to prevent systematic effects, as well as selected data, from introducing bias in the resulting conclusions.

As stated earlier, the regression technique is a study of the relationship between two or more variables. While this technique has been briefly discussed from the standpoint of insulation systems and the evaluation of their lives, it may be used for any data for which any type of functional relationship is desired. In its analysis this technique not only answers the question as to how well an assumed relationship holds, but also furnishes the parameters for expressing the relationship in mathematical form. It must be remembered that any estimated relationship is valid only over the range of the experimental conditions. Extrapolation is most unwise, except when there is a sound theoretical basis.

Digest of paper 56-177, "A Statistical Method for Predicting Insulation Life from Experimental Data," recommended by the AIEE Committees on Rotating Machinery and Dielectrics and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

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Cathode Instability in Argon Atmospheres

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EXTENSIVE experimental and analytical studies have provided a basic understanding of the manifestation of arc cathode instability relative to fluctuations of arc voltage as influenced by electrical, chemical, and geometrical parameters. These studies have contributed significantly to the development of controlled cathode stabilization systems of the argon-shielded consumable electrode arcs as applied to the welding of mild steel.

Cathode instability observed as a wandering action of the arc flame over the negative terminal of the arc takes the form of an extension of the flame above the tip of the consumed electrode when using straight polarity (electrode negative), or a spreading of the arc cathode flame on the workpiece when using reverse polarity (workpiece negative). This condition occurs when electrode and workpiece surfaces have been stringently cleaned to remove impurities.

Geometrical considerations of the welding arcs include physical shape of the arc terminals and of the arc terminal surfaces affected with respect to time. The cathode of the arc is strongly influenced by the body and surface chemistry of the negative arc terminal. The quantities of some materials and their accessibility, as influenced by the geometry of arc terminals, play a part in the arc characteristics.

One geometrical aspect, when considering the surfaces over which the cathode flame travels, applies only for nonconsumed electrodes under stationary conditions, that is, with zero welding travel speed. It is assumed that the areas on the workpiece, over which the cathode flame can freely move, are essentially flat surfaces and those on the electrode are cylindrical. The total circular area covered by the cathode when at the workpiece is πM^2 where M is a limit of wandering from the center beneath the electrode (Fig. 1*c*). With the cathode at the electrode, the area covered is the total wall surface of a cylinder plus one end, and is represented by $\pi DM + \pi D^2/4$ or $\pi D(M + 0.25D)$ where D is the diameter of the electrode and M is the linear extent of cathode wandering up the electrode (Fig. 1*d*). The M limit is assumed to be the same for each polarity (Fig. 1*a* and 1*b*).

A different geometrical aspect arises when the electrode and flat workpiece move with respect to each other and the electrode is fed into the arc as its tip is being consumed. New surfaces containing traces of oxides or other foreign material on both the workpiece and electrode are then continually being introduced. With the cathode on the workpiece, the area covered over a period of time would be a rectangular swath with semicircular ends, i.e., circular areas displaced along a straight line (Fig. 1*e*). The rate at which new workpiece surface area is introduced is a function of linear arc travel speed. With the cathode at the electrode (straight polarity) new end electrode surface area as well as new cylindrical surface area is continuously being made available (Fig. 1*f*).

The consumption rate of a given size electrode increases with current. The rate of consumption can conceivably be sufficiently rapid or the welding travel speed sufficiently slow so that the rate at which new surface is made available to the cathode on the electrode may be equal to or greater than the rate at which new surface is made available to the cathode on the flat workpiece. This is confirmed experimentally by the decrease in the per-cent time of rise to a higher arc voltage with higher currents. With reverse polarity, an increase of arc current and a constant welding travel speed produces an opposite condition. For that case the per-cent time for which the higher voltage is experienced increases greatly at about 300 to 325 amperes, indicating insufficient surface impurities are available on the workpiece to maintain an arc at the lower voltages and the higher arc currents. The influence of limited impurities present at the cathode can be experimentally observed with a variation of arc current. The transition to a predominantly higher value level of arc voltage indicates that the lower voltage arc cannot be supported above the critical current of about 300 amperes. This critical current may shift to higher values if more impurity is made available to the cathode.

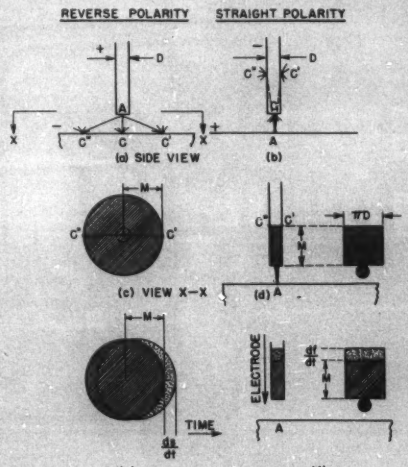

Fig. 1. Geometry of welding arcs in argon

Digest of paper 56-110, recommended by the AIEE Committee on Electric Welding and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956. Scheduled for publication in AIEE *Applications and Industry*, 1956.

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Electromagnetic Chuck with Instantaneous Emergency Feature

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An electromagnetic chuck with an important safety feature has been designed at Penn State's Ordnance Research Laboratory. With this device, the danger of injury as the result of power interruption or failure is eliminated.

WHEN AN ELECTROMAGNETIC CHUCK is used to hold work for grinding, a positive danger exists that failure of chuck power when the grinding wheel is in contact with the work will result in injury to the operator and damage to the work and machine. To remove this danger, a simple and relatively inexpensive device has been designed at the Ordnance Research Laboratory, The Pennsylvania State University, that insures a continuous flow of current to the chuck when a failure of the normal chuck power source occurs.

This device provides direct current to the electromagnetic chuck by rectification of the normal a-c power and switches to a stand-by power source without interrupting the flow of current in the magnet coils of the chuck whenever the normal alternating supply voltage falls below a fixed value. The switching element is a dry-disk diode. Instantaneous switchover to stand-by power, which takes place during a-c power interruptions or supply voltage dips, occurs whether the failure lasts only a few cycles or continues for a long period. The normal power supply automatically resumes supplying chuck current as soon as a-c power of the proper voltage is restored.

Fig. 1. Magnetic chuck power supply installation

Two methods of ensuring safety have been suggested by manufacturers of electromagnetic chucks. In the first, the grinder and its chuck are to be powered from a common a-c source so that a power failure that disables the chuck will also shut down the grinder. In the second, a fail-safe relay is employed that, when de-energized by the loss of a-c power, switches the chuck to stand-by batteries.

The instantaneous switchover feature of the new device provides safer machine operation than does either of the methods suggested. It does not have the disadvantage of the method that utilizes a common supply for chuck and grinder, that the grinding wheel might contact and damage the work while it is slowing down after a power failure. In addition, chuck current is not interrupted during the switchover, thus eliminating a danger which exists when a fail-safe relay is used—the possibility that the work will be displaced if the wheel is in contact with it during the significantly long relaxing time of the relay.

In the installation for which the new power supply was developed, the possibility of chuck power failure at a critical instant had been avoided by powering the chuck from a bank of wet storage batteries at all times. Although this method insured safety, continuous routine maintenance, recharging, and replacement of the batteries were required. Furthermore, it was necessary to maintain two complete banks of batteries to make one available while the other was being charged. The combined requirements for maintenance personnel, special handling facilities, space, and replacement costs made this system unattractive.

The use of the new power supply is as safe as continuous connection to a wet-battery bank and, in addition, is an improvement in other respects:

1. The space requirement is small (Fig. 1 shows a complete installation).
2. Maintenance costs are low.

A special article recommended by the Machine Tools Subcommittee of the AIEE Committee on General Industry Applications.

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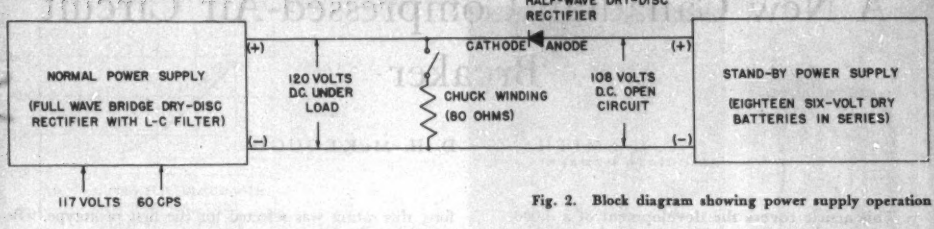

Fig. 2. Block diagram showing power supply operation

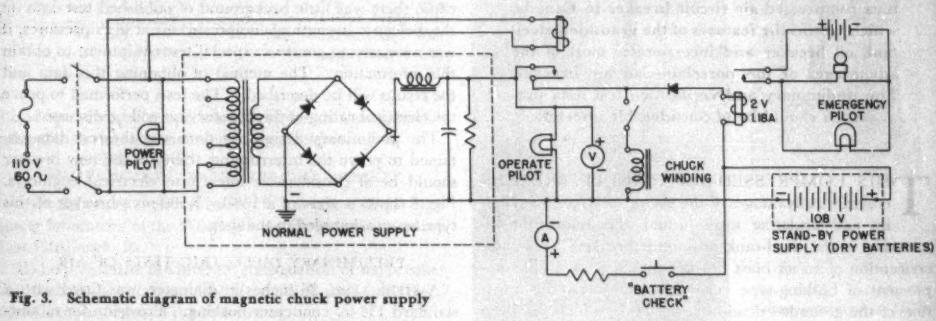

Fig. 3. Schematic diagram of magnetic chuck power supply

3. The stand-by power supply consists of 6-volt dry-cell batteries, and replacements costs are relatively low since useful battery life is essentially its shelf life.

4. The need for special handling facilities is eliminated.

The operation of the power supply is shown in block-diagram form in Fig. 2. The normal power supply is a conventional filtered full-wave bridge rectifier operating from the a-c supply line. Its direct terminal voltage when supplying current to the chuck winding is 120 volts. The stand-by power supply consists of 18 6-volt "hot shot" dry-cell batteries connected in series. This number was chosen to make the open-circuit terminal voltage of the battery supply slightly less than the voltage across the chuck in normal operation. The output of the normal power supply is connected through the chuck switch to the chuck terminals. The stand-by power supply is connected to the chuck in the same polarity as that of the normal supply but the connection is made through a half-wave rectifier.

In normal operation, the higher voltage of the normal supply places the cathode of the series rectifier at a higher potential than its anode, and this difference in potential disconnects the stand-by supply from the circuit. If, for any reason, the output voltage of the normal power supply falls below that of the stand-by battery supply, the series rectifier conducts, and there is a smooth transition from one source of current to the other. The current in the chuck windings assumes a new steady value determined by the terminal voltage of the batteries under load minus the rectifier drop.

If the failure of the normal power supply output is only momentary, the normal power supply automatically takes over, supplying the chuck current as soon as its voltage is back to normal. For longer interruptions, of course, the tool or wheel is backed off from the work, and the chuck switch is opened to avoid discharging the batteries while the a-c power failure is being corrected.

Fig. 3 is a schematic circuit diagram of the device. In addition to the filtered rectifier power supply, the dry-disk switching diode and the stand-by battery supply that have been discussed, a battery test circuit, a warning circuit, and a disconnect relay are shown. When the "BATTERY TEST" switch is closed, the condition of the stand-by batteries under load is indicated by the deflection of the 0.5-ampere ammeter. A red index is marked on the ammeter at the reading corresponding to the lowest activity of the batteries at which they will still provide safe chuck holding current. When the current indication falls below this index in a battery check, the batteries are replaced.

During emergency operation, current from the stand-by batteries flows through the low-voltage operating coil of the warning relay. This relay operates, sounding a bell and energizing a light to signal abnormal operation.

The purpose of the disconnect relay, the contact of which is in series with the normal power supply and the chuck, is to avoid any discharge of the stand-by battery through the back resistance of the rectifier during periods when the chuck is not in use and the power supply is shut down. The fact that this relay will drop out during a power failure of more than a few cycles has no effect on the operation of the emergency feature.

The installation pictured in Fig. 1 has been in service at the Ordnance Research Laboratory since 1953. Over this period, it has operated successfully during power failures of both long and short duration. The batteries installed have been used for over two years and are still serviceable.

A New Canadian Compressed-Air Circuit Breaker

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This article covers the development of a 5,000-mva compressed-air circuit breaker in Canada, which retains the features of the grounded-steel-tank oil breaker and incorporates most of the advantages of the porcelain-clad air breaker. The preliminary and verification test data presented should be of considerable interest.

THIS COMPRESSED-AIR CIRCUIT BREAKER embraces advantages of the use of air as an interrupting and insulating medium and, also, retains the advantages of the dead-tank oil circuit breaker. This new conception of an air-blast breaker provides for a full complement of bushing-type current transformers, the retention of the grounded dead-tank principle, which has been North American practice, and the retention of the conventional capacitor-type bushings, which provide a source of low potential for meters and relays. The excellent dielectric properties of compressed air permit an appreciable reduction in tank size. The simple pneumatic and electric controls eliminate the necessity for large operating mechanisms and interphase linkages. The result is a reliable air-blast breaker with conventional North American features.

In Canada, the bulk of the high-voltage power distribution is at the 115- to 138-kv level. For some time it is expected that 5,000-megavolt-amperes (mva) interrupting capacity at these voltage levels will be adequate. Therefore, this rating was selected for the first prototype. Because there was little background of published test data on the dielectric strength of compressed air at high pressures, it was necessary to construct special test equipment to obtain this information. The method of obtaining this data and the results will be described. The tests performed to prove the electrical rating of the breaker also will be discussed.

The preliminary design test data and the test data obtained to prove the interrupting ability of the new breaker should be of considerable interest to electrical engineers. Fig. 1 shows a view of a 138-kv 3,500-mva breaker of this type being assembled in the shop.

Fig. 1 (above). A 138-kv 3,500-mva compressed-air circuit breaker. Fig. 2 (right). Experimental tank for dielectric tests on high-pressure air

PRELIMINARY DIELECTRIC TESTS OF AIR

A STEEL TANK, 26 inches in diameter, was fitted with a standard 138-kv condenser bushing. Provision for mounting various electrode shapes to the lower end of the bushing and to the bottom of the tank was made through a convenient hand-hole in the side of the tank. Fig. 2 shows this tank setup in the shop during the testing period.

A variety of electrode shapes was selected to simulate the possible contours that were expected to be used in the proposed prototype.

Breakdown tests were made with the standard $1^1/_2 \times 40$ microsecond impulse and 60-cps waves at pressures ranging from atmosphere up to 250 pounds per square inch gauge (psig). Creepage tests were made for various creepage distances at atmosphere and at the estimated minimum working pressure of 200 psig. Fig. 3 shows a curve of 60-cps breakdown plotted against tank pressure for a given electrode configuration. Fig. 4 shows a curve of impulse breakdown voltage plotted against tank pressure.

Curves for many electrode configurations corroborated the findings of earlier investigators,[1,2,3,4] that for specific conditions a critical pressure range exists where the breakdown strength dips and beyond which the dielectric strength increases again. Design of high-voltage apparatus insulated by compressed air must take cognizance of this characteristic.

Another significant fact observed is that the increase in the breakdown strength of air, both for the impulse wave and

Full text of paper 56-217, "A New Canadian Compressed-Air Circuit Breaker," recommended by the AIEE Committee on Switchgear and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

C. C. Smith and D. H. McKeough are with the Canadian Westinghouse Company, Ltd., Hamilton, Ont., Canada.

The authors wish to thank the switchgear personnel of Westinghouse Electric Corporation, East Pittsburgh, Pa., and in particular B. P. Baker, J. E. Schrameck, and R. E. Kane for their enthusiastic support, and technical advice and assistance.

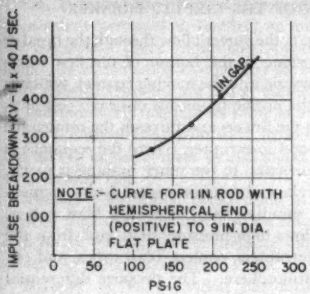


Fig. 3. Typical 60-cps breakdown curve for compressed air

the 60-cps wave, as the pressure is increased, is considerably greater than the increase in creepage strength.

CONSTRUCTION OF THE CIRCUIT BREAKER

A SINGLE POLE, as shown in Fig. 5, was tested in the high-power laboratory of the Westinghouse Electric Corporation, East Pittsburgh, Pa.

To help visualize the internal construction of the breaker, Fig. 6 shows a cutaway view of one-pole unit, and Fig. 7 shows a cross section of the interrupter.

Referring to Fig. 6, a conventional grounded steel tank is shown filled with air at a pressure of 250 psig having an elliptical manhole for access to the tank. With the breaker standing closed on the line, high-pressure air exists in the tank, in the interrupters, inside the moving contacts, down through the coolers and blast tubes to the top of the blast valves. With the blast valves mounted at the outlet of the blast tubes, the bleeding of air through the interrupters and blast tubes to prevent condensation is not required. Also, the blast valves are easily accessible as a control point. High-pressure air at the contacts increases the dielectric strength of the contact gap very rapidly which adds to the efficiency of the interrupter. It also permits isolating the circuit with the relatively short gap available at the main contacts. In this way, the necessity for a sequential isolating switch, such as is normally incorporated as part of the breaker structure, is eliminated.

The problem of deionizing and cooling the arc gasses and metallic vapors was solved by mounting a cooler directly under the interrupter. This cooler houses a cartridge-type

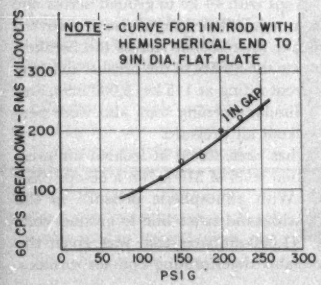
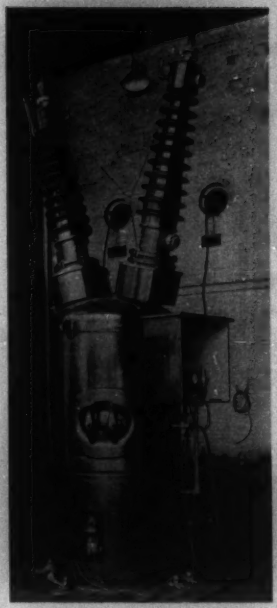

60 CPS BREAKDOWN-RMS KILOVOLTS
NOTE:- CURVE FOR 1 IN. ROD WITH HEMISPHERICAL END TO 9 IN. DIA. FLAT PLATE
300
200
100
1 IN. GAP
0 50 100 150 200 250 300
PSIG

Fig. 4. Typical impulse breakdown curve for compressed air



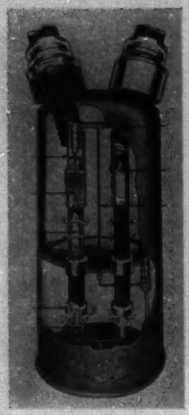


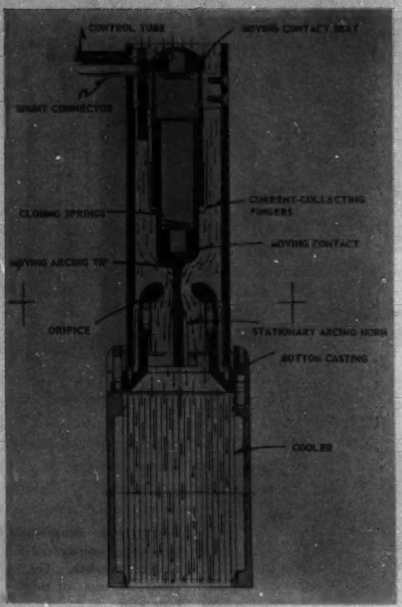
Fig. 5 (left). Single-pole prototype compressed-air circuit breaker. Fig. 6 (top). Section of single-pole unit

unit having a very high rate of thermal transfer and yet offering negligible resistance to the air flow.

Each interrupter is designed for a nominal voltage of 69 kv and an interrupting rating of 2,500 mva. For any multiple of this voltage and mva rating, the interrupters are arranged in series electrically and in parallel pneumatically. The use of shunt capacitors to grade the voltage equally across each break assures that each unit takes its share of the load electrically. The symmetrical arrangement of the interrupters prevents the arc energy at one break from influencing the air flow at another. At the same time, the use of identical interrupters, blast valves, etc., for different ratings permits greater manufacturing activity with reduced costs, and simplifies the problem of spare parts for the customer.

The terminal bushings are of the conventional capacitor type and are connected to the interrupters through flexible shunts, so that no precise alignment of the bushing is necessary and no adjustments are required at assembly. The lower porcelain is solder-sealed to the metal parts of the bushing and the lower end is given a hydraulic test at 600 pounds per square inch (psi) to ensure air tightness.

Fig. 8 shows the interior of the control cabinet, which is mounted on the center tank and houses all the electric and pneumatic controls except the control valves which are located within the skirt of the center tank. All customer's connections come into the bottom of this cabinet. Included are relays, terminal blocks, fuses, switches, thermostat, pressure gauge, nonreturn check valve, hand valve, safety valve, pressure alarm and lockout switches, push buttons to trip



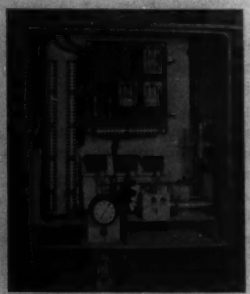


Fig. 7 (above). Section of interrupter and cooler during arcing. Fig. 8 (left). Interior of control cabinet

and close manually, auxiliary switches, heater, and a flag to indicate the breaker open or closed. The safety valve limits the pressure in the tank to 10 per cent over the normal operating pressure and the check valve prevents air from flowing back out of the breaker should there be a temporary drop in supply pressure. The lockout switch renders the breaker electrically inoperative if the pressure should drop below 200 psi and the alarm switch provides a warning at 15 psi above this point.

The air supply for up to five of these breakers is provided by a compressor unit with an air storage tank located in the switchyard close to the breakers. This unit will pump and store air at 600 psi. Through reducing valves, oil filters, and chemical driers, the air is delivered to the breakers at 250 psig with a dew point in the breaker tanks at less than −50 F.

OPERATION OF THE CIRCUIT BREAKER

Referring to Fig. 6, the current flow through the breaker is in through one bushing to the bottom of the first interrupter, through the nozzle into the moving contact, which is held closed against the nozzle by means of heavy compression springs, through the fingers and through the removable connector to the second interrupter, where the sequence is reversed and the connection to the other bushing is made.

When protective relays operate on system faults, a pneumatic control valve simultaneously opens all blast valves. This immediately allows high-pressure air to rush from the tank through the interrupters, coolers, blast tubes, and out the blast valves to atmosphere. The pressure differential across the nozzle causes the nozzle to snap down approximately 3/4 inch; this action, in conjunction with the air blast, draws the arc between the silver tungsten button on the moving contact and the arc-centering electrode. The arc is interrupted by the air blast. Deionization takes place in the coolers below the interrupters. During this time, another pneumatic control valve which is interlocked pneumatically with the first valve has operated, and after the blast valves have been opened a predetermined time, it dumps high-pressure air from behind the moving contacts. This contact opens by the force of high-pressure air on its lower end to provide 3 inches of separation of the contacts. The blast valves close, halting the flow of air. The time of closing is a predetermined setting and this actually takes place approximately 8 cycles after initiation. This permits the nozzles to move up against their stops while the moving contacts remain in the upper position, thus isolating the circuit.

To close the breaker, the action of the second control valve is reversed and high-pressure air is brought in behind the moving contacts. This pressure allows the biasing springs to close the contacts. The breaker remains in both the open and closed positions without holding voltage on any coils and without any excessive air leakage.

TESTS

A single-pole unit of this circuit breaker has been successfully tested to cover the following ratings: 115 kv, 1,200 amps, 3,500 mva, 5 cycles; 115 kv, 1,200 amps, 5,000 mva, 5 cycles; 138 kv, 1,200 amps, 3,500 mva, 5 cycles; and 138 kv, 1,200 amps, 5,000 mva, 5 cycles.

Fig. 9 shows magnetic oscillograms of an 0–15-seconds operation of the breaker interrupting 29,000 and 21,000 amperes in 3.6 and 3.3 cps with 44 kv to ground across one interrupter, and with an equivalent rate of rise of recovery voltage of 1,100 volts per microsecond across the breaker. These amply demonstrate the ability of the breaker to interrupt in excess of its current rating at 115 kv, 5,000 mva, and 138 kv, 5,000 mva. Similar opening tests also were performed down to the lockout air pressure.

The 138-kv breaker has been tested at lockout air pressure to prove its insulation level of 310 kv on a 60-cps basis and 650-kv impulse. With atmospheric pressure in the tank, the breaker will withstand twice line to ground voltage. A momentary 41,000-amperes test was given the breaker without appreciably deteriorating contact surfaces

Fig. 10 shows the effect of increased tank pressure (and consequent increased air density) on the temperature rise of the contacts. These values correspond to a 1,200-ampere load. It is interesting to note that the compressed air in the tank cuts the temperature rise at normal operating pressure to approximately one half its value at atmospheric pressure.

Line-dropping tests also were performed to demonstrate the ability of the breaker to disconnect 150 miles of 115-kv transmission line.

Voltage distribution tests,[6] done at 60 and 1,600 cps, proved that the capacitor grading shunts used across each gap do an effective job of dividing the voltage equally between the two interrupters in series.

Because of its grounded steel-tank construction, this compressed-air breaker is remarkably rugged and stable, and does not subject long porcelain columns to high internal pressure, as is done in many compressed air designs.

The tanks are registered pressure vessels and serve as large local air receivers containing the air for insulation and arc extinction and, also, providing a source of stored energy for operating the breaker contacts.

Economics of installation and foundation design are afforded by the absence of ground shock when interrupting. The tanks are somewhat smaller than those of a conventional 3-tank oil breaker, and a little less station space is required than for an oil breaker and most air-blast breakers. The absence of a conventional closing mechanism and operating linkage requires no critical lineup of the tanks.

The arrangement of the terminal bushings is simple and provides for a full complement of 12 bushing-type current transformers and 6 potential devices.

Maintenance can be carried on inside the tank in all kinds of weather, and there is no oil to drain or filter.

Effective air seals are obtained by the use of standard "O" rings where the terminal bushings and blast tubes pass through the tank. The elliptical manhole in each tank is of the type used in steam boilers.

The interrupter contacts, blast valves, control valves, and auxiliary switch operator represent the only moving parts in the breaker, since there is no linkage between the controlling elements and the contacts. These parts are readily accessible for maintenance. Contacts are inspected by removing the interrupters from the tanks and separating the nozzle assemblies from the interrupters. The total time required with 2 men working is 20 minutes per tank.

The power arc is quickly moved on to the silver tungsten buttons, which are separate from the main contact surfaces. This fact together with the extremely short arcing time of 1/2 to 3/4 cycles, assures long contact life with low maintenance.

Inasmuch as the interrupters are mounted directly in the

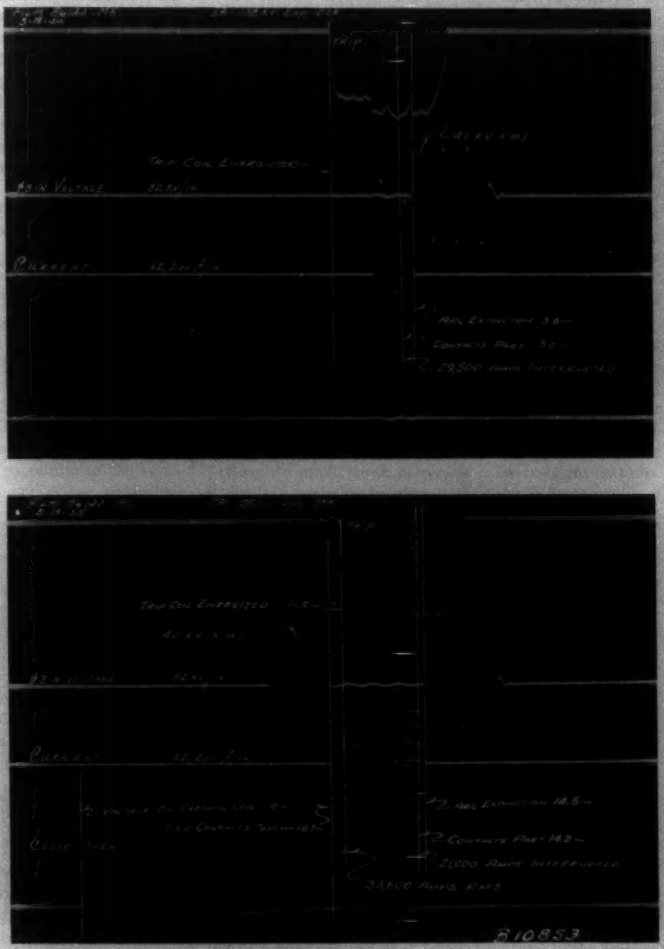


Fig. 9. Oscillogram of 0–15-seconds interrupting test

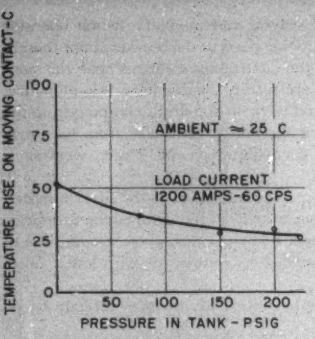


Fig. 10. Curve showing effect of air pressure on temperature rise inside tank

high-pressure air, full-tank pressure always is available at the gap even before the contacts separate. This assures an extremely fast buildup of dielectric strength across the gap, producing a very efficient interrupter.

The blast valves are protected from the weather by removable louvers, which are normally closed by light biasing springs. Low-wattage "dew point" heaters are provided to prevent condensation inside the control housing and under the tank skirts. The control tube from the interrupters is protected from the entrance of atmospheric moisture, when the breaker contacts are in the open position, by a lightly biased spring check valve.

All operating parts are contained inside the tanks or within the weatherproof control housing and tank skirts, so that there is no hazard of dust or foreign particles lodging on sliding surfaces such as interrupter contacts.

Because no bleeding of air is required in either the open or the closed position of the breaker, air consumption is kept to a minimum. The hazard of moisture condensing on the blast tubes also is eliminated, inasmuch as the blast valves are at the exhaust end of the blast tubes. At the same time, the tank provides for a large volume of stored air at the interrupters so that four CLOSE–OPEN operations are possible without drawing on air stored in the compressor station.

CONCLUSIONS

VALUABLE DATA regarding the dielectric characteristics of air at high pressure have been obtained. A high-speed air-blast breaker, retaining the features of North American grounded-steel-tank oil breakers, incorporating most of the advantages of porcelain-clad air breakers and excluding most of the disadvantages has been developed and tested successfully in four ratings, namely: 115 kv, 1,200 amps, 3,500 mva; 115 kv, 1,200 amps, 5,000 mva; 138 kv, 1,200 amps, 3,500 mva; and 138 kv, 1,200 amps, 5,000 mva. The development of this breaker has provided considerable know-how and design data to permit the development of higher and lower voltage ratings with their appropriate interrupting ratings already proved.

REFERENCES

1. The Electric Strength of Air at High Pressure, **H. H. Skilling**, AIEE *Transactions*, vol. 58, 1939, pp. 161–5.

2. Breakdown Studies in Compressed Gases, **A. H. Howell**. AIEE *Transactions*, vol. 58, 1939, pp. 193–206.

3. The Electric Strength of Air at High Pressure, Pt. II. **H. H. Skilling, W. C. Brenner**. AIEE *Transactions*, vol. 60, 1941, pp. 112–5.

4. High-Pressure Gas as a Dielectric, **G. C. Nonken**. AIEE *Transactions*, vol. 60, 1941, pp. 1017–20.

5. Capacitance Control of Voltage Distributionin Multibreak Breakers, **R. C. Van Sickle**. AIEE *Transactions*, vol. 56, 1937, pp. 101 8–24.

Scientists Study Sweep of Glacial Ice Sheet

The last great sheet of glacial ice in North America covered Milwaukee, Wis., as recently as 10,700 years ago, atomic-type tests at Yale University have disclosed.

Richard F. Flint, Professor of Geology at Yale, said recently that dating of glacial samples by means of radioactive carbon—the well-known Carbon 14—has given scientists their first accurate picture of the sweep of the last great ice age into northern America. Other tests are under way to date other areas covered by ice at Yale's Geochronometric Laboratory, set up in 1952. Ultimately, an accurate geologic picture of the extent and dates of ice sheets in America will be gained.

Radioactivity is present in all living organisms. After death this radioactivity decays at a constant known rate. When 5,568 years have elapsed, half of the radioactive carbon is gone. What remains is again reduced by half after another 5,568 years, and so on.

The last great ice sheet, previously thought to have covered the northern United States up to 25,000 years ago, actually pushed down across the continent only about 3,000 years before the earliest recorded civilization in Egypt. From samples collected by various field geologists and shipped to Yale, it has been possible not only to say that the Milwaukee area was covered by an ice blanket hundreds or thousands of feet thick, but to chart the rate of advance of the glacier.

The glacier covered a vast region, stretching from what is now Duluth, Minn., across the Great Lakes to Lake Champlain in New York State. It swept southward at about 960 feet a year, stopping in the Milwaukee area; after covering Milwaukee for a few hundred years it began to recede. By 8,200 years ago, it had receded to the vicinity of Green Bay, Wis., 170 miles north of Milwaukee, which means it melted away at the rate of about 345 feet a year. By 6,500 years ago, the great ice had melted from all of the Great Lakes region.

Willard F. Libby, a member of the Atomic Energy Commission, first developed the Carbon 14 tests, and in 1951 estimated that ice had covered the Great Lakes region perhaps as recently as 11,000 to 12,000 years ago. The Yale measurements have confirmed this estimate. Atomic tests of two samples found northwest of Hudson Bay, for example, have proved that the glacial ice sheet covered that area as recently as 4,000 years ago.

Noise Reduction in Communication Channels

L. S. SCHWARTZ
MEMBER AIEE

THE DEVELOPMENT of communication theory has led to the introduction of concepts such as integration, correlation, matched filtering, "comb" filtering, probability of detection, etc. Much confusion centers about their significance because of functional equivalence and because of inadequately defined purposes in their use. Thus, it may be overlooked that integration and correlation are equivalent operations, or that matched filtering or comb filtering are techniques of integration. The purpose in using these concepts can be understood properly only within frameworks of suitable criteria of performance. For example, it is frequently assumed that the end object of a filtering technique is to improve the signal-to-noise ratio, whereas it is actually a means to an end. This end is to increase the information rate over a communication channel or to increase the probability of detection of a search radar, etc.

Because of frequent confusion about the use of terms and the nature of objectives, it seems desirable to discuss some basic objectives in the communications problem and to see how filtering concepts fall into perspective.

In communications, the concern is transferring a steady flow of information or a fixed amount of information from one point to another. For transfer, of either a steady flow or fixed amount of information, maximum reliability is desired. In communication terms, transmission with maximum reliability is equivalent to transmission with minimum probability of error. The probability of error here is that resulting from the presence of noise in radio or radar receivers. It is convenient to minimize the probability of error according to either one of two equivalent approaches. The first is the criterion approach and consists in guessing whether the signal is present or not according to some criterion. The operator may make one of two kinds of errors. He may report the signal present when, in fact, it is not (called a false alarm), or he may report it as not present when, in fact, it is (called a miss). The criterion approach involves a ratio, called the likelihood ratio, for a given receiver, defined as the ratio of probability for that receiver input if there is signal plus noise to the probability if there is noise alone.

The alternative to the criterion approach is to ask: If there is a noisy waveform in the receiver output, what is the probability that a signal is present? This is the method of inverse probability, which also involves the likelihood ratio. The optimum receiver for detecting signals in noise, according to the criterion or inverse probability approaches, is one which maximizes the likelihood ratio. If the detection process is synchronous demodulation, both approaches show that the optimum receiver is a cross-correlation device, assuming thermal noise at the input to the receiver. If the detection process is envelope detection, both approaches show that the optimum receiver has a log-I_0 detector followed by an integrator, again assuming thermal noise at the input to the receiver. For small signals a log-I_0 detector behaves as a square-law detector and for large signals as a linear detector. Because small signals are suppressed by large noise in envelope detectors, the receiver should be a cross-correlation device if the noise is larger than the signal for appreciable periods of time. If the reverse is the case, it is immaterial whether cross-correlation or envelope detection receivers are used.

Implicit in the operation of optimum receivers is the existence of a threshold device at the output of the receiver. If the signal-to-noise ratio is increased, this threshold can be raised with a resulting reduction in the probability of error. The criterion or inverse probability approaches show that there is an optimum way of improving the signal-to-noise ratio; for thermal noise, the optimum way is by the use of linear filtering.

Because of the evident importance of linear filtering, it is of interest to establish analytically that the previously mentioned forms of linear filtering are equivalent and that they may be considered simply as different methods for performing correlation. Then it is useful to consider in what ways the principle of correlation is applied in some well-known applications possessing noise resistant features. Basically, correlation involves finding the average values of the product of two time functions separated by a fixed delay time.

One method of detection which may be used to avoid the noise suppression of weak signals is synchronous detection. In this method, the signal at the transmitter is carrier-modulated by a cosine wave which is synchronized with the local oscillator signal in the receiver. At the receiver, the incoming cosine-modulated wave is demodulated by the local phase-coherent local oscillator wave. The demodulation process is multiplication. The demodulated signal is then passed through a low-pass filter, a process akin to integration. Thus, except for the scale factor involved in averaging, the procedure resembles correlation. A study of CW (continuous wave) and FM radars shows that these systems, which are highly noise resistant, are fundamentally cross-correlation devices. Actually, the principle of correlation is used in one form or another in almost all communication and radar devices, but usually with considerably less than maximum efficiency. The pulsed amplitude-modulated radar is an example of a device which, with the addition of a delay network at the second detector of the receiver becomes an autocorrelator.

Digest of paper 56-74, "Principles of Noise Reduction in Communication Channels," recommended by the AIEE Committee on Communication Theory and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956. Scheduled for publication in AIEE *Communication and Electronics*, 1956.

L. S. Schwartz is with New York University, New York, N. Y.

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New Membership Qualifications

R. A. HEISING
FELLOW AIEE

A number of changes were made in the AIEE Constitution in 1955, the majority of which deal with membership qualifications. The new requirements and the reasoning behind these requirements are outlined.

IN 1955, the Constitution of the Institute was amended. Most of these amendments were directed toward changes in membership requirements. Increases in experience requirements for Associate Member and Member grades were made to bring them into agreement with the Engineers' Council for Professional Development (ECPD) recommendations. The changes allow for a more equitable schedule of credits for academic education. Other important changes will be discussed in greater detail in the subsequent paragraphs.

THE NEW QUALIFICATIONS

NOTE: Deleted words are printed in *italics;* words added are in **bold face.**

Qualifications for grade of Member

SEC. 5—At the time of *application for* admission or *transfer* **advancement** to the grade of Member the applicant shall be at least 30 years of age and engaged in active practice in the electrical field (temporary unemployment excepted). He shall have had at least *seven* **ten** years of active practice of the profession in one or a combination of several branches of the electrical field, indicative of growth in competency and achievement in that field and of a character satisfactory to the Board of Directors. Graduation in an engineering curriculum of an educational institution approved by the Board of Directors shall constitute *one year* **four years** of this requisite of *seven* **ten** years *and possession of a license as a Professional Engineer issued by a legally constituted Board whose requirements for licensing are considered adequate by the Board of Directors shall be considered equivalent to three years of the requisite seven years* of practice. In addition he shall qualify under one or more of paragraphs "a" to "d" of this Section. To qualify under paragraphs "a", "b" or "c", he shall have been in good standing in the grade of Associate Member for a period of at least two consecutive years immediately prior to the date of application for grade of Member **or, as an alternative, he shall have had at least three additional years in active practice during which time he shall have been in responsible charge of work as described in paragraphs "a", "b" or "c".**

a. An electrical engineer by profession. As such he shall be qualified in and have had responsible charge for at least two years of important electrical design, construction, manufacture or operation.

b. A teacher of electrical engineering or electrical science. As such he shall be capable of teaching a major course in one or more fields of electrical science or engineering and shall have had responsible charge for at least two years of an electrical course in a school of electrical engineering or allied science approved by the Board of Directors.

c. A person working in the field of electrical engineering or electrical science who, by inventions, original work or by proficiency in electrical science, the electrical arts or electrical literature or as an engineering executive of an electrical enterprise of large scope or the application of electricity to engineering projects, has attained a standing equivalent to that required for Member grade under paragraphs "a" or "b".

d. A person who holds in good standing in a cognate engineering society of national scope in any country a grade of membership for which the qualifications indicate a standing equivalent to that required for Member grade under paragraphs "a" or "b".

Qualifications for grade of Associate Member

SEC. 6—At the time of *his application for* admission or advancement to the grade of Associate Member the applicant shall be at least 21 years of age and shall be: (1) A graduate of an engineering curriculum that is approved by the Board of Directors or (2) if not such a graduate, he shall have equivalent attainments, including *five* **six** years of increasingly important engineering experience indicative of growth in engineering competence and achievement and of a character satisfactory to the Board of Directors. *He shall be either:* **In either case the applicant shall be:**

a. *An electrical engineer by profession. As such he shall be* **Qualified**, under instruction and supervision to undertake electrical design, construction, manufacture or operation, **or**

b. *A teacher of electrical subjects. He shall be* **Qualified**, under supervision **to** teach **electrical** subjects required in a curriculum approved by the Board of Directors.

SUMMARY OF CHANGES

THE CHANGES of immediate interest to members and applicants may be summarized as follows:

For Member Grade:

1. The experience requirement is now 10 years instead of the prior seven years;

2. The credit against experience for graduation from an approved curriculum is now four years instead of the prior one year;

R. A. Heising, consulting engineer, is chairman of the AIEE Board of Examiners.

3. Six years of suitable experience is required of a graduate of an approved curriculum (no change from the prior situation);

4. Credit for possession of a Professional Engineer's License was removed from the Constitution and modified credits inserted in the Bylaws;

5. An applicant who is not an Associate Member or who does not come under paragraph 5d of the Constitution may now be admitted directly to Member Grade if he has 13 years' acceptable experience of which five years have been in responsible charge of important work.

For Associate Member Grade:

1. The experience requirement is now six years instead of the prior five years if not a graduate of an approved curriculum;

2. The applicant does not have to be either a practicing electrical engineer or a teacher in an approved curriculum but he must be *qualified* for beginning work in one of those fields. Student members may file their applications before graduation.

The increased experience requirements are in accordance with suggestions from ECPD made several years ago. Many societies have been raising their qualifications and some have made changes similar to these several years ago.

One change made deserves an explanation. The provision for experience credit for possession of an approved Professional Engineer's License was removed from the Constitution for two reasons: one was that due to the wording there was a possibility of duplicating credit for both the license and the prior experience; second, that possession of a Professional Engineer's License is a legal requirement for certain jobs and did not properly belong with technological qualifications. However, the Professional License may still contribute to determining an applicant's qualifications as will be mentioned later.

An important new provision in the Constitution is as follows:

> "Sec. 9. The Board of Directors may establish alternate, but at least equivalent, qualifications for all grades of membership except Fellow by means of appropriate Bylaws."

This new provision permits the Board of Directors to correct inequalities and injustices existing at present and prepare for the broadening of the technological base of electrical engineering without filling the Constitution with minute details. It may prevent the periodic revising of the Constitution.

EDUCATIONAL CREDITS

UPON THE APPROVAL of the Constitutional amendments, the Board of Directors immediately adopted a Bylaw (Sec. 4) authorizing the Board of Examiners to propose to the Board of Directors credits for graduation from other curricula than those now accredited. This is in accordance with ECPD suggestions. The Board of Examiners has given this matter considerable study. For one thing, they do not want to get into the curriculum evaluation business. The Examiners have enough work to do without entering other fields. They are, however, feeling their way and plan to go at it slowly. The Examiners have already come up with a few proposals, and they have now been approved by the Board of Directors. The initial step is to make use of the accomplishment of the nonaccredited graduate for determining the amount of credit to be given for his education.

At the same time, the Board of Examiners finds many physicists and mathematicians entering the engineering field. The technological art is being broadened to encompass more of the field of science than ever before. Much engineering work now requires training that an accredited curriculum graduate has not had. Concerns employing many engineers have been employing mathematicians and physicists for some years in their research and development work and find that they develop into as good engineers as do engineering graduates. At the same time, the colleges have been directing their curricula more and more towards fundamentals, which means physics and mathematics, and reducing their orthodox engineering courses. It would appear desirable for the Institute to recognize these changes and prepare to welcome into its ranks those in the engineering field who started their careers with training in science. Some credit for their education is therefore now provided by the new action of the Board of Directors.

The educational credit that is to be given is expressed as follows:

> "An applicant for admission or transfer who is not a graduate of a curriculum approved by the Board of Directors may be recognized as having received an education justifying three years' credit toward the required experience for Associate or Member grade where:
>
> "He is a graduate in engineering, engineering science, mathematics major in arts, or engineering science major in arts, from a four-year course in an institution granting degrees provided he has demonstrated the acceptability of his education by one of the following:
>
> (a) He has been promoted to a position of responsible charge of important engineering work within four years of graduation, or
>
> (b) He has had a technical paper accepted for publication in the publications of the Institute or a paper of equivalent technical calibre published elsewhere, or
>
> (c) He had made an invention in the electrical field and supplies the Board of Examiners satisfactory evidence that it has been put into commercial use and that he is considered in his organization to be the inventor thereof, or
>
> (d) He has received a Professional Engineer's License from a State Registration Board whose requirements are approved by the Board of Directors."

GRADUATE WORK

AT THE SAME TIME the Board of Examiners gave some study to the subject of graduate work in engineering, physics, and mathematics. Again industry has been the first to recognize that graduate study is often of more value

to the engineer and his employer than engineering experience. Industry usually recognizes this by giving a larger salary increment to the man with an advanced degree than for an equivalent amount of time spent in engineering. The Board of Directors has therefore approved giving some credit for graduate work that has led to advanced degrees, as follows:

> "Credit for graduate work against experience for Member grade may be allowed in addition to that allowed for undergraduate work where the applicant has received an advanced degree from an educational institution that in the opinion of the Board of Examiners provides adequate training. The credit may be one only of the following:
> (1) One year for a Master's Degree, or
> (2) Three years for a Doctor's Degree,
> where such graduate work is in engineering, engineering science or mathematics provided such credits do not provide duplicate credit for engineering or teaching experience time that is submitted as part of the specified 10 years."

INSTITUTE ACTIVITIES

THE STANDING COMMITTEES of the Institute, and the Sections, do much very valuable work for the engineering profession. Much time and effort are expended by these Committees and the Section officers in carrying out their tasks that are of so much use to the membership. The Board of Directors has agreed that certain of this work deserves recognition in the case of applicants for Member grade. The Board therefore has included in its resolution the following:

> "Service by a member as Chairman of any standing Institute committee of the AIEE, or as Chairman of a Section, may be recognized by the Board of Examiners as responsible charge of important engineering work and may be so counted toward the required experience for Member grade. If the applicant is engaged in other engineering or teaching work while holding such chairmanships, the time must not be counted twice toward the required experience."

PROFESSIONAL REGISTRATION

With respect to the provision of credit against experience for the possession of an approved Professional Engineer's License, it is to be noted in the credits listed in the foregoing paragraph that the graduate of an unaccredited four-year engineering curriculum who secures an approved Professional Engineer's License, may have his technical education recognized to the extent of three years' credit toward membership.

At the same time, it might be pointed out that when the new amendments to the Constitution went into effect, the Board of Directors, by means of Bylaw Sec. 6, recognized the possession of an approved Professional License as *prima facie* evidence that the applicant has had professional experience of a caliber acceptable for Associate Member and Member grades, and the four years' experience upon which his Professional License application was based may be accepted as experience toward those grades even though it may be secured in other than the electrical engineering field.

SUGGESTIONS TO APPLICANTS

THESE CHANGES, many of which remove inequities among applicants, naturally inject new details into the qualifications for the membership grades. Many engineers will be able to make application for admission or transfer sooner than previously possible without these changes. The Board of Examiners expects to have its work increased both by the greater number of applications submitted, and by the necessity for checking applications against the new qualifications. There will be a greater likelihood than in the past that the justifying qualifications for admission or advancement may be missed as the applications are handled by the Board.

The applicants can assist in avoiding these embarrassing happenings if they will take the trouble to point out in their applications the items that justify the grade for which they applied. It should be mentioned here that the members of the Board of Examiners often have much difficulty at present in determining from the brief outline of experience found in some applications whether the applicant is actually doing engineering work, or how important the work is. Continued efforts to get applicants and references to supply a good story seems to secure only partial results. Many applicants seem to think that if they give the name of their employers, and the titles of their jobs, that enough information is thereby supplied to the Board. The number of employers in the electrical field is so prodigious that many times no one among 30-odd Board members at a meeting can remember ever hearing of most employers. The applicant can, therefore, increase his chances of approval by the Board if he will supply information which is sufficiently detailed to indicate the nature of the engineering work he performs.

The principal stumbling block for applications for Member grade is showing that the applicant has had responsible charge of important engineering work. This qualification is almost the first thing a Board member looks for in a Membership application. It should be pointed out clearly even to the extent of using the words "responsible charge." There should then be supplied some information supporting the statement, such as the number of other engineers or employees supervised, and/or the caliber of the work that renders it important.

The Board of Examiners is hoping that the new qualifications will be more advantageous for those in the engineering field who are qualified. The greater the number of engineers who are Members, the greater will be the Institute's service to the profession. The Board is hoping that the Transfers Committee in the various Sections can resurvey their membership in the light of these qualifications. It is also hoped that the Transfer Committee can sit down with the possible applicants, giving them assistance by taking a careful look at their qualifications and pointing out the combination that justifies the grade for which an application might be made. Assistance of this kind will be appreciated by the Board of Examiners.

Power-Line Carrier Application

J. D. MOYNIHAN
MEMBER AIEE

E. G. ALLYN
ASSOCIATE MEMBER AIEE

RAPID LOAD GROWTH during the past few years has dictated the installation of new high-voltage transmission lines through densely populated urban areas served by The Detroit Edison Company. Overhead construction, being much cheaper, is preferred; however, right-of-ways difficulties or local ordinances may require underground construction or at least the use of a section of underground cable in a high-voltage line. A composite line of this description was selected to supply new Northwest Station and, also, serve as part of a system tie between existing Northeast and Evergreen Stations.

The line, shown in Fig. 1, together with the all pipe-cable line between Evergreen and Northwest was scheduled to be completed prior to completion of Northwest Station. It was planned that the two sections of overhead and the two sections of pipe-cable be operated and relayed initially as one line. When the station at Northwest was completed, the line would be sectionalized, each part then being relayed as a separate line. The relaying would therefore be required to be initially suitable for the temporary composite line between Northeast and Evergreen Stations and later lend itself to conversion when the line was sectionalized at Northwest Station.

It is the usual practice to specify relaying, which will provide for instantaneous clearing of faults at both terminals of a pipe-cable line simultaneously. This has been suitably obtained with dual a-c pilot wire relaying combined with superimposed d-c remote-trip relaying, using four specially insulated pilot wires in a spare duct of a presently installed 24-kv cable duct run. This type of pilot-wire installation was not feasible between the terminals of this line in existing duct runs, and the prohibitive cost of new installation of ducts encouraged investigation of the possibilities of using power-line carrier or microwave channels as the means of providing comparable protection.

Inasmuch as either power-line carrier or microwave would permit the use of directional distance carrier relaying and remote tripping initiated from both terminals, the determination of the best choice of relaying had to be based primarily on economic considerations.

Power-line carrier was found to be cheaper, since no other service was required that would normally share the cost of a microwave system. It was then necessary to determine whether satisfactory signal margins were possible over the composite line and select optimum frequencies for the initial and final line configurations.

The first study showed that signal levels over the entire

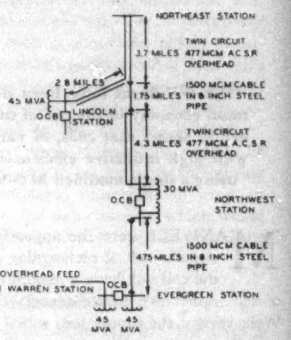

Fig. 1. Combined cable and overhead circuit under consideration

line from Evergreen to Northeast would not permit satisfactory carrier operation and that the line should be sectionalized. There appeared to be no problem in operating carrier satisfactorily over the all pipe-cable section between Northwest and Evergreen Stations, therefore the study was concentrated on the composite line between Northwest and Northeast Stations to determine optimum carrier frequencies.

The input impedance and real and apparent attenuation values for the composite line were calculated by digital-computer processes at 5-kc intervals from 40 kc to 200 kc.

From the computer results, curves of attenuation and input impedance were drawn. A frequency allocation chart made for the existing carrier channels in the vicinity of Northeast Station showed the unoccupied areas of the frequency spectrum at the Northeast bus. The frequencies for the three channels were determined from the data. The frequencies selected were 142 kc for the directional-comparison channel, and 101 and 99 kc for the remote-trip channels.

The line traps and line tuners were tuned to the selected channel frequencies. The apparent attenuation and noise were measured in a small range near the selected frequencies. From these measured values, the known input impedance of the line, and the carrier transmitter power output, it was calculated that there was 20-db reserve for the impedance relaying channel and 30-db reserve for the remote-trip channels. These signal margins are adequate for reliable relaying performance.

The signal levels were measured with the carrier channels in service, and the line-attenuation figures predicted were found to be slightly pessimistic.

It is believed that this type of study is possible for the most complex line problem and is practical as a means of predicting carrier performance on a proposed line in the design stage.

Digest of paper 56-65, "The Application of Power-Line Carrier to a Combined Cable and Overhead Circuit," recommended by the AIEE Committee on Carrier Current and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

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Inductive Efficiency of Reactive Coils

H. B. BROOKS
FELLOW AIEE

"M-S-W" forms have been designed for maximum economy in the use of coil material. This article shows that coils, of various inductances, with high inductive efficiencies may be wound using a single modified M-S-W winding form.

MAXWELL gave the approximate proportions of a circular coil of rectangular cross section for which the coil will have a maximum time constant (ratio of self inductance to resistance). Later, Shawcross and Wells revised the proportions stated by Maxwell.

Coils to serve as laboratory standards of self inductance usually have widely spaced values—for example, 1, 10, 100 millihenries—consequently, there is no reason why they may not be made of different physical dimensions. In at least one modern industrial application, however, coils to cover a very large range of closely spaced values are required. To wind each one of these coils in an individual M-S-W (Maxwell-Shawcross-Wells) form, for maximum economy in the use of material would require an unduly large number of winding forms and would complicate the procedure, thus tending to offset the economy of material.

This article shows that a single winding form may be used, of M-S-W proportions but with extended circular flanges, so that coils may be wound of depths ranging (for example) from 1/2 to 2.5 times the depth corresponding to M-S-W proportions; and that the coils over all this range will have inductive efficiencies of 95 per cent or higher. The term "inductive efficiency" is proposed as denoting the ratio of the time constant of any coil to the time constant of the coil which would be made by rewinding the wire of the coil as a new coil of M-S-W proportions.

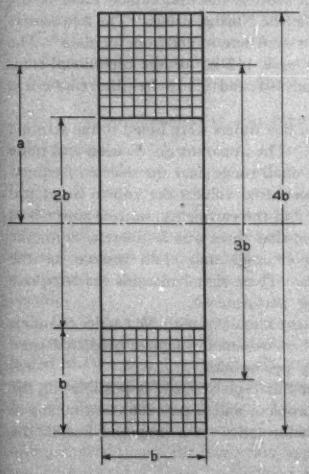

Fig. 1. Relative dimensions of a reactive coil, M-S-W form, in terms of b, the axial breadth of the winding

In general, the useful property of a reactive coil is its self inductance; the unwanted property is its resistance. The self inductance of a coiled wire depends greatly on the form of the coil. The accepted optimum form of coil is one first derived approximately by Maxwell[1] and later, to a higher degree of precision, by Shawcross and Wells, with the principal dimensions given in terms of b, the axial breadth of the square cross section. The inner diameter, mean diameter, and outside diameter are respectively $2b$, $3b$, and $4b$. The design of such coils has been treated in detail in another paper.[2] Because standards of inductance are ordinarily of distinctly different magnitudes, such as 1, 2, 5, 10 . . . millihenries, it was assumed in this previous paper that each such coil ("standard") would be wound in the optimum form, of a size suitable for its purpose, which would have no necessary relation to the size of any other inductor of a group.

However, in some industrial uses of reactive coils, a relatively large number of coils must be provided for each piece of manufactured apparatus, the inductances of these coils forming a series ranging from a low to a high value by small steps. It would be a manufacturing hardship to require that each individual coil should be wound, M-S-W manner, in a form used for it only. The question thus arose, cannot each winding form be used, not only for the coil for which it is exactly suitable, but also for several coils of closely graded values larger than and several others of closely graded values smaller than the one of ideal form? The answer evidently depends on two things, namely, the possible saving of investment and labor by reducing the number of winding forms which must be provided, stored, and handled, and on the other hand, the cost of the extra copper required for a given time constant when the depth of winding is greater than, or less than, that which gives a square cross section. The first question is one which the manufacturer must decide; the second is the subject of this investigation.

BASIS OF NORMAL COIL DESIGN

REFERRING TO FIG. 1, which shows the optimum form of coil, Maxwell's approximate formula for the self inductance L is:

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$$L = 4\pi a N^2 \left(\log_e \frac{8a}{G} - 2 \right) \quad (1)$$

where

L = inductance in abhenries (millimicrohenries)
a = mean radius of cross section of coil in centimeters
N = total number of turns in the coil
G = geometric mean distance of the cross section of the winding in centimeters. (The geometric mean distance of a rectangle of sides b and d may be taken as equal to $0.2236\,(b+d)$. In previous literature this quantity has been denoted by the symbol R. The author regards this practice as confusing, and prefers G because R is universally used as the symbol for resistance.)

In the case of a coil with sides b and d, G may be written as $0.2236\,(b+d)$, and equation 1 becomes

$$L = 4\pi a N^2 \left(\log_e \frac{8a}{0.2236(b+d)} - 2 \right) \quad (2)$$

A very convenient simplification is possible by transforming equation 2 to read

$$L = 4\pi a N^2 \left[\log_e \frac{8a}{b+d} - \log_e (0.2236) - 2 \right] \quad (3)$$

But $\log_e (0.2236) \approx -1.5$

Hence, finally

$$L = 4\pi a N^2 \left(\log_e \frac{8a}{b+d} - \frac{1}{2} \right) \quad (4)$$

If $b = d$ (square cross section), and $a = 3d/2$ as in the M-S-W case, the equation becomes very simple because $8a/(b+d)$ then equals 6. The more general equation 3 is necessary for all cases in which b is not equal to d, or a does not equal $3d/2$.

EFFECT OF VARIATIONS

THE ORIGINAL PLAN of the present attack on this problem was as follows: assuming a form suitable for the winding of coils of M-S-W proportions, but with the sides of the form extended outwards in order that coils of radial depth greater than normal can be wound, determine by analysis the time constant of coils wound to depths less than, and also greater than, the depth for M-S-W proportions. From the volume of the utilized winding space in each case, compute the dimensions of a theoretical coil of M-S-W proportions of equal volume, and its time constant. This latter value is the maximum time constant attainable with the given wire, and the ratio of the time constant of the actual over- or under-wound coil to this computed maximum attainable value gives a numerical measure of the concession that must be made in departing from the M-S-W proportions. The term "inductive efficiency" is proposed for this ratio.

This procedure was carried out, and values of inductive efficiency were computed for closely spaced winding depths ranging from 1/20 of the normal depth for square cross section to 3 times the normal depth. For depths below the normal, the results were about what might be expected; the inductive efficiency fell off, at first gradually, then more and more steeply, as the depth of winding diminished. However, for coils of radial depth greater than the depth for square cross section the results were astonishing; for twice normal depth, for example, the efficiency was only slightly under 95 per cent. A coil of twice the normal depth has an inductance 5 times as large as the inductance for normal depth, with a resistance 2.6 times as great as the resistance for square cross section. These results indicated the possibility that the object sought could be realized to an extent far greater than had been anticipated. They also raised an important question, namely, whether results like this, obtained by mathematical analysis based on an *approximate* formula, could be safely used as a basis for actual manufacture. Rosa's more accurate modification[3] of Maxwell's formula gives for the optimum form of coil a value of inductance 5 per cent lower than that given by the approximate formula that is used in the foregoing procedure. Because the results of the present investigation were to be utilized if they were promising, in an actual manufacturing establishment, it was considered imperative to wind an actual coil, the resistance and inductance of which would be measured at the completion of each layer, as well as the diameter of the winding.

EXPERIMENTAL COIL

THE COMPLETED COIL is shown in Fig. 2. The form is made of seasoned wood, put together solely with plastic resin glue. It is arranged to rotate in bearings of like construction. During the winding, the small coil, shown mounted on the bobbin shaft, was not present. (This small coil is a replica of the *first layer* of the large coil. It is shown to help the reader visualize the great radial depth of the main coil.) The wooden shaft was extended several feet to operate a counter which showed at all times the number of turns of wire on the bobbin. The counter is reversible, a feature of great convenience when the necessity arose for unwinding, and then rewinding, a number of turns which had not gone on the coil as smoothly and regularly as desired. The hub of the bobbin is 51 mm in diameter, and the distance between the sides of the winding space is one-half this value; hence a radial depth of winding of 25.5 mm corresponds to the M-S-W form. Had the actual coil consisted of "non-embedded" layers, 20 layers would

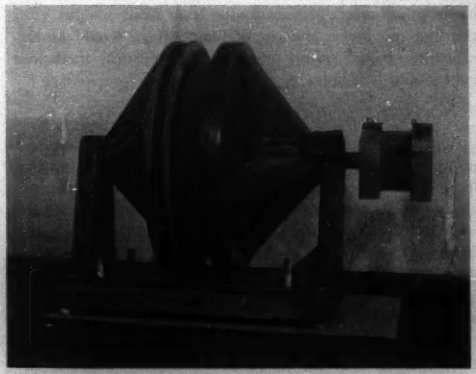

Fig. 2. Experimental reactive coil of 50 layers, 20 turns per layer

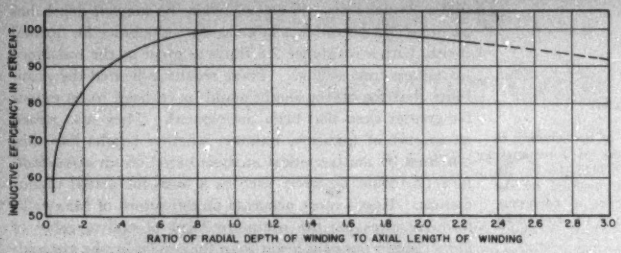

Fig. 3. Curve of inductive efficiency of the experimental coil as a function of the ratio of the radial depth of winding to the axial length of winding

have brought the depth of winding up to 25.5 mm, and this coil would have been of M-S-W form. Actually, 22 layers had a winding depth of 25.4 mm, indicating a gain in compactness of winding because of embedding.

The wire used is number 17 AWG copper, insulated with enamel plus one wrap of silk. The completed coil of 50 layers contains 3.2 kilograms of wire.

The outside diameter of the coil was measured at the completion of each layer, by wrapping a thin steel tape line around the coil and reading the circumference to the nearest 0.1 mm. From the diameter, obtained from the observed circumference, the thickness of the tape was subtracted.

At the end of each layer, the resistance and inductance were measured. Because of the large temperature coefficient of copper, the attempt was made to keep the room temperature at the initial value (23 C). This attempt was fairly successful up to the finish of the 16th layer, when 24 C was the nearest attainable value. This condition was closely approximated through the rest of the winding operation. All values of resistance obtained with room temperature other than 23 C were reduced to this value. There still remains the question of the heating of the wire by friction as it passed through the operator's gloved hands to the coil. To eliminate this would have required a period of waiting after the completion of each layer, for thermal equilibrium with the surrounding air. Heating of the wire from this cause would affect principally the layer being wound. For the first few layers the rise of temperature would be significant. However, no practical use of such inefficient coils would be made.

COMPUTATION OF INDUCTIVE EFFICIENCY

THE METHOD OF COMPUTATION used is based on one of a number of general relations concerning self and mutual inductance of geometrically similar coils.[4] These relations apply to coils wound of wires of the same resistivity and the same density, and also (where so stated) of the same space factor. The particular relation used reads as follows: "(i) For coils wound with wires having the same space factor the time constant L/R is proportional to the square of a given coil dimension."

The method can best be illustrated by an actual example. When 44 layers (twice the number for M-S-W form) had been wound, the self inductance was 61.2 millihenries and the resistance was 4.655 ohms. The corresponding values for the M-S-W case of 22 layers were 12.3 millihenries and 1.754 ohms. The time constants were 7.01 milliseconds for 22 layers and 13.15 milliseconds for 44 layers.

The ratio of mass of wire, 44 layers, to the mass at 22 layers is equal to the ratio of the corresponding resistances 4.655/1.754 = 2.653. The side of the square cross section of an imaginary coil of M-S-W proportions, which the actual mass of wire at 44 layers would make, will be greater than the side of the square cross section of the actual 22-layer M-S-W coil by the factor, cube root of 2.654, namely, 1.3845. The time constant of the imaginary coil will be equal to the square of 1.3845 times 7.01 (the time constant of the actual 22-layer coil), or 13.44 milliseconds. Finally, the inductive efficiency of the actual 44-layer coil is equal to the quotient of its actual value, 13.15 milliseconds, divided by the ideal value, 13.44 milliseconds, or 97.8 per cent.

The results of the measurements on the actual coil are shown in the curve in Fig. 3. Up to a radial depth of 0.5 of that for square cross section this curve follows closely the corresponding part of the curve determined by mathematical analysis. As the depth of winding progresses beyond that for square cross section, the observed values of inductive efficiency exceed those found by analysis, and at 2.3 times the depth for square cross section the observed value of inductive efficiency is about 5 per cent greater than the value found by analysis. The part of the curve for abscissas 2.3 to 3.0 is extended with consideration of the corresponding part of the curve determined by analysis.

It may be shown that by winding wire of a given size and thickness of insulation in a single such form, to winding depths ranging from 0.5 to 2.25 times the depth for M-S-W proportions, values of self inductance ranging from the lowest up to *30 times* the lowest can be obtained; that the inductive efficiency of the coils of lowest and highest self inductance will be 95 per cent; and that the average efficiency of all the coils will be approximately 98.5 per cent.

This result is another surprising overthrow of a tradition which has gone unchallenged for generations. A similar case[5] concerned the dependence of bridge-measurement sensitivity on galvanometer resistance. The moral is: in any new case in which mathematical analysis reveals that some desired functioning or property is a maximum for a certain set of conditions, further analysis should be made to determine the degree of sharpness or flatness of the maximum.

REFERENCES

1. Electricity and Magnetism (book), **J. C. Maxwell**. Vol. 2, sec. 106.

2. Design of Standards of Inductance, and the Proposed Use of Model Reactors in the Design of Air-Core and Iron-Core Reactors. United States National Bureau of Standards *Journal of Research*, Washington, D. C., vol. 7, 1931, pp. 289–328. Research Paper No. 342.

3. United States National Bureau of Standards *Bulletin No. 8*, Washington, D. C. 1916, p. 136. Scientific Paper No. 169.

4. Design of Standards of Inductance, etc., *op. cit.*, pp. 296–7.

5. Sensitivity of a Galvanometer as a Function of Its Resistance, **H.B. Brooks**. United States National Bureau of Standards *Journal of Research*, Washington, D. C., vol. 4, 1929, p. 297. Research Paper No. 150.

The Favorite

An Ethical Problem in Procurement

C. T. CHAVE

THE ACCEPTED METHOD of purchasing engineering equipment is by competitive bidding. The problem presented here is the problem of the favorite. Let us assume that for one reason or another we have settled on a favorite supplier of synchronous motors. We are convinced that this is the right and the only equipment to recommend. We are now faced with several ethical questions, such as:

How can we justify our position and avoid taking competitive bids?
If we have taken this position, do we have a right to ask for competitive bids?
If we are forced to ask for competitive bids, should we arrange to purchase our favorite product by devious means?

It is customary in engineering to make a comparison of bids in which design features, components, guaranteed performance, terms of sale, and price are compared item for item. This is the best system we can devise in lieu of experience. It is a mental exercise which impresses the young engineer especially. It is, however, somewhat defective. It seems as though some machines with all the wrong features give successful performance for years, whereas some theoretically excellent products fall down miserably. Perhaps this is because we cannot include in bid comparisons the ability of the workmen and the integrity of their management. Perhaps it is because we put weight incorrectly on the comparative features. At any rate, there is no substitute for experience.

In the case of the favorite, ethical problems exist only for the man who is spending other people's money. An owner may do what he likes. He may accept gifts as large as the donor wishes to give, he may accept lavish entertainment to any extent, and he may select the successful vendor on any whimsical basis he chooses. Any man purchasing equipment should examine his personal position first. Is it his money, or is he free to spend the money as his own? Most engineers have a responsibility to someone else. An employee has a responsibility to the owner; a public utility engineer, for example, has a responsibility to the directors, stockholders, and a public utility commission; and a consulting engineer has a responsibility to his client. Public work especially is surrounded by rules designed to insure equal treatment of citizens and prevent chicanery, even at the price of also insuring mediocrity and inefficiency.

Perhaps, then, the first justification for playing favorites may be found in some set of rules. The rules of private business may not always specifically require competitive bidding, but they do require justification of procurement actions upon investigation. On this basis, one may feel he has the right to say that since he has always had satisfactory and fair dealings from his favorite maker and vendor, he is justified in not seeking competition. The danger in this action is the tendency toward smugness. How can anyone say that Smith equipment is best if he has not at least investigated Jones equipment?

Certainly we must give the newcomer a chance. What should be the rules in this case? Should we clearly define when the bid is hopeless and when we are about to give the bidder serious consideration?

Private companies only take a few bids, the minimum usually being three. Is there not the same ethical problem with taking many bids, thus reducing each bidder's chances while subjecting him to expense? About three years ago a chemical plant was contracted for, with eight prime bids and revised bids by at least three runners-up. Each contender in turn took bids from several machinery suppliers. This effort probably cost industry over half a million dollars; about six per cent of the cost of the plant. Have we a right to subject industry to this expense? Is it a reflection on his engineering ability that no discrimination was used by the purchaser? In past practice, especially in Europe, the problem has been given recognition by paying for proposals on designed-to-order equipment and plants. This practice is out of date—should it be?

Finally, let us suppose that we are forced to take many competitive bids without discrimination, and that we still have one or more favorites. Should we rig this deal? Certainly we know that some bidders are incompetent. How do we get rid of them? One need not associate with criminals to think of a few methods. We can make it hard on the fly-by-nights by allowing a short time to submit proposals, by demanding elaborate tenders and erecting all kinds of technical hurdles. We can be ruthless in regard to conformity with the bidding rules, and reject poor bids on technicalities. Finally, we can tell our favorites about the competitive offerings and show them how to bid successfully. To outward appearances, such a course is identical with that pursued when favoritism is induced by less noble motives than the desire to buy the best equipment. That is why sealed bids are customary in public work. I am sure we would condemn such a course. Yet, is it ethical to allow your client, your company, or your town to buy inferior products because the rules allow incompetent equipment suppliers to bid?

These are questions our profession must answer.

A special article recommended for publication by the AIEE Committee on Code of Principles of Professional Conduct.

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Ammeters Boost Efficiency of Modern Machines

J. E. HYLER

The use of ammeters as indicators of per cent of motor load on machine tools is becoming more and more widespread. They provide excellent motor protection, eliminate unnecessary stoppages, and permit the operator to exercise a high degree of control.

THERE IS, in the machine-tool field, a continuing increase in the application of motor load per-cent indicators. They are used in various ways and for different reasons, although their primary function is indication of the relative load or loads of one or more a-c motors on a given machine. As made by one manufacturer who has specialized in these devices, the indicator hand travels over a scale having a range from zero to 150 per cent of motor load. The section of the scale from 125 to 150 per cent is blocked off in red, to indicate danger and warn of overloading.

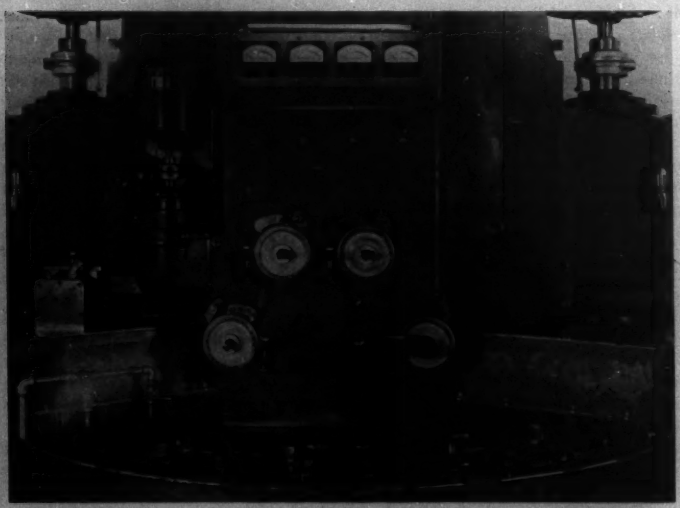
Where a motor load per-cent indicator, or an ammeter developed for this purpose, is properly applied, it will give a continuous and visible check of actual load conditions on any a-c motor. In some cases, the same ammeter is made suitable for use on 1-, 2-, or 3-phase; also 2-, 3-, or 4-wire a-c motors of any horsepower, commercial frequency, or voltage. An adjustable-ratio transformer is used in connection with the ammeter to provide this versatility.

Use of an ammeter in this way is often helpful to the machine manufacturer, because it allows each motor to be set to proper workload for the operation it is to perform. By this means, therefore, overmotoring can be prevented, resulting in economy. In operation, motors can be maintained at 100 per cent full load, provided load level is constant. If the load cycle varies, the motor can be maintained at the ideal operating condition, thus permitting a machine operator to tell readily how heavy a cut to take and how fast a feed to use. Foremen and supervisors acquainted with the ammeter can also tell whether or not a machine is functioning properly in reference to motor load being employed.

TOOL-CHANGE TIME

AS TOOLS DULL, other things being equal, the motor load progressively increases. Therefore, the ammeter is employed in many instances for determining when tools should be resharpened or replaced. Obviously, in this sense, the ammeter is a direct aid to quality control, in consideration of the fact that tools do not do good work when they become too dull.

There are many other instances on various types of machines in other segments of industry where motor load can be definitely connected to quality control. In the chemical and other industries where different materials are batched and mixed to some standard consistency, for instance, it is easy to see that motor load on a mixer is defi-



Courtesy Mattison Machine Works

Fig. 1. Working area of a multiple-spindle grinder equipped with four grinding spindles. Four ammeters, corresponding to the spindle motors, are in view just above the working area

A special article recommended by the Machine Tools Subcommittee of the AIEE Committee on General Industry Applications. Scheduled for presentation at the Machine Tools Conference, Cincinnati, Ohio, October 22-24, 1956.

J. E. Hyler is with John E. Hyler and Associates, Peoria, Ill.

nitely related to consistency of the mix. Therefore, indication of a specific motor load percentage can easily be a signal of the right time to mix in another material, to load, to dump, etc.

Application of ammeters to surface grinding machines has proved particularly advantageous. By watching grinding spindle motor load on an ammeter, the operator has definite means of adjusting depth of cut and feed rate properly. It is obvious that on some materials, a deeper cut can be removed at a given motor load than on others.

WHEEL-DRESSING TIME

Moreover, the progressively growing load on an ammeter under given operating conditions at the surface grinder, caused by dulling of grits on the wheel, gives an operator the opportunity to know when the proper time has arrived for wheel dressing. This allows him to use his wheel or wheels an optimum length of time, so no waste is involved in dressing too often, yet allows him full insurance against using them too long between dressings.

On multiple-spindle grinders, such as those made by Mattison Machine Works, where several motors are used on a single machine tool, ammeters are particularly valuable in helping an operator maintain proper relative loads on various spindles for best over-all production (Fig. 1). The same thing is found in the woodworking field, particularly with reference to multiple drum sanders, like those made by Solem Machine Company. Here, an ammeter is applied to the directly-mounted motor on each sanding drum (Fig. 2).

By observing these ammeters while the machine is at work, an operator is able to distribute properly the full sanding load over the several drums. Drum sanding machines in this line have as few as two drums in an occasional case, but those chiefly employed are four-drum endless-bed sanders, and eight-drum double-deck machines, the latter making a high-production showing where Douglas fir plywood and other flat softwood materials are sanded both sides at once in high volume.

These double-deck 8-drum machines actually incorporate 16 ammeters, in two sets of eight each. Eight of these ammeters (one for each drum) are located across the front of the machine where they can readily be consulted by the operator. The other eight are mounted at the rear, where they can be seen by the off-bearer; these can also be seen by the operator when making actual drum adjustments.

When surface grinders are working on a cut where the full surface of the wheel is engaged, the cut and feed are generally set so the motor is under full load or more, the purpose being to use a wheel which can adequately employ the full amount of power provided, when other conditions are right. Thus, the ammeter guides an operator in adjusting to proper depth of cut and correct feed.

It is very important that an ammeter be so located that it will be readily visible to the operator in his usual position. In some cases, it may be mounted directly at the motor. In most instances, however, it will be placed at some distance from the motor, in order to be visually convenient for the operator.

OTHER MACHINES

Certain leading manufacturers of centerless grinders have adopted ammeters as standard equipment on some of their models. So applied, their use in evaluation of immediate workloads while in operation can always be expressed in terms of increased production. Should the workload indicator signal the fact that the machine is operating with a reserve of available horsepower, steps can be taken to alter the situation. On the other hand, should the fact be signaled that the machine is being overloaded in its motor horsepower, measures can be initiated to avoid costly damage.

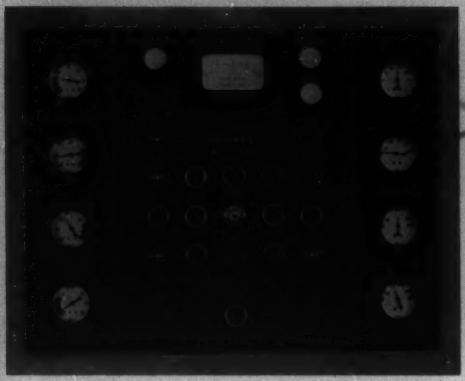
One interesting aspect of using an ammeter to indicate cutting-tool condition is found in a large 2-way horizontal broach, made by Cincinnati Milling Machine Company (Figs. 3 and 4). On this unit, as the ammeter begins to climb out of its full-utilization range into an indicated overload condition, the operator is continually aware that

Courtesy Solem Machine Company

Fig. 2. Endless-bed 4-drum sander operating in the plant of P. A. Starck Piano Company, Chicago, Ill. Ammeters are located directly adjacent to motors whose working loads they show

Courtesy Cincinnati Milling Machine Company

Fig. 3. View of a 2-way horizontal broach equipped with a work-load indicator at the center length of the machine



Courtesy Cincinnati Milling Machine Company

Fig. 4. Instrument panel for the 2-way horizontal broach shown in Fig. 3; at top center is the ammeter, designated as the load indicator.

cutting edges of his tools are beginning to lose their efficiency, and that they will soon require replacement.

Undoubtedly, industry has lost heavily on many machines where ammeters would have reduced or eliminated such loss greatly. Much of this comes from the fact that operators in general do not have a very close understanding of the load they can place and maintain on a motor. In some cases, therefore, an operator has persistently overloaded a motor and burned it out. In other instances, where a motor was not provided with overload protection, timid operators have kept a machine on exceedingly low load, to play it safe.

SUPERIORITY TO OVERLOAD RELAYS

WHERE MOTORS have been protected by overload relays, automatically stopping them at or a little before the danger point, it has been found that stopping a motor while in operation may be extremely inconvenient. Sometimes, where tungsten carbide cutters are involved, tool breakage has resulted.

Without question, the ammeter is more effective. Its use makes proper motor protection visual, yet leaves time of actual motor stoppage or change in the hands of the operator. To this, of course, are added various advantages contingent on being able to watch the motor load at all times, thus permitting operation at optimum efficiency.

Large Mobile Over-the-Road Substations Shipped

Two mobile unit substations, believed to be the largest ever built for over-the-road use, have been shipped from the General Electric Company's Power Transformer Department in Pittsfield, Mass. Each is a complete electric substation, with transformer, switchgear, lightning arresters, and controls, mounted on a highway trailer. Each has a capacity of 7,500 kva.

The units have been purchased by the Illinois Power Company. From bases at Belleville and Decatur, Ill., they were hauled to the utility's permanent substations to maintain electric service while regular equipment is shut down for routine maintenance. They will also be available for emergency duty.

Each unit substation, including trailer, weighs 25½ tons and is 31 feet long, 8 feet wide, and 13 feet high.

INSTITUTE ACTIVITIES

Appliance Technical Conference
To Be Held in Milwaukee, Wis., May 14–15

THE 7TH ANNUAL Appliance Technical Conference which is sponsored by the AIEE Committee on Domestic and Commercial Applications, will be held in Milwaukee, Wis., May 14–15, in the Wisconsin Hotel.

The program of this year's conference is built primarily around the subject, Motor Driven Appliances; however, several papers on other subjects are also to be included. There will be a discussion period following each paper, and audience participation is encouraged. Copies of the papers will be available at each session.

In order to facilitate matters, those interested in attending are asked to register in advance. Name, address, and an indication of plans to attend should be sent to: Donald Ziemer, Allen Bradley Company, 136 West Greenfield Ave., Milwaukee 4, Wis. The registration fee of $3 for both members and nonmembers is payable at the conference. There will be no charge for enrolled student members and immediate families of members.

An inspection trip to the Milwaukee Hotpoint Plant is planned for Monday evening. Those attending are asked to indicate on their advance registration cards whether they intend to make this trip.

The Wisconsin Hotel will have rooms available for those who wish to attend the conference.

The tentative technical program is as follows:

Monday, May 14

9:00 a.m. Registration—Mezzanine

9:45 a.m. Session I—Ballroom

Presiding: H. F. Hoebel, chairman, AIEE Committee on Domestic and Commercial Applications

Welcome to Milwaukee: J. A. Deubel, chairman, Milwaukee Section AIEE

Keynote Address: "The Appliance Business Uncontrolled." James H. Dunham, Wisconsin Electric Power Company

Automatic Armature Testing. *D. C. Krammes*, The Hoover Company

Acoustical Problems in Motor Driven Appliances. *G. L. Wolfert and S. A. Zimmerman*, General Electric Company

12:00 Noon Luncheon—Circus Room

1:30 p.m. Session II—Ballroom

Presiding: B. F. Parr, chairman, AIEE Subcommittee on Domestic Appliances

Household Electric Dishwashers. *T. H. Swisher*, Hotpoint Company

The Evolution of a Food Waste Disposer. *E. E. Wiecorek*, In-Sink-Erator Manufacturing Company

Fundamentals of a Combination Washer-Dryer. *J. G. Jacobsen*, Westinghouse Electric Corporation

Refrigerator Cycling Performance Calculated with an Analogue Computer. *R. Prucha*, General Electric Company

Evening: Inspection Trip to the Milwaukee plant of the Hotpoint Company. Details of trip and transportation arrangements will be announced at morning and afternoon sessions.

Tuesday, May 15

9:30 a.m. Session III—Ballroom

Presiding: G. E. Schall, Jr., Underwriters' Laboratories Inc.

Underwriters' Laboratories, Inc., Test Procedures and Listing Requirements for Motor Driven Appliances. *R. M. Knourek*, Underwriters' Laboratories Inc.

Panel Discussion: "Test Procedures and Specifications for Motor Driven Appliances," G. E. Schall Jr., moderator. R. M. Knourek, Underwriters' Laboratories, Inc. W. A. Fuller, Whirlpool-Seeger Corporation. D. J. Harbour, General Electric Company. J. F. Dexter, Dow Corning Corporation. E. O. Morton, Westinghouse Electric Corporation.

Appliance Timers. *Dan Stolle*, International Register Company

12:00 Noon Luncheon—Circus Room

1:00 p.m. Session IV—Ballroom

Presiding: Truman Cline, Newark Stove Company

Appearance Design Trends in Appliances. *Brooks Stevens*, Brooks Stevens Associates

Improving Appliances with Silicones. *J. F. Dexter*, Dow Corning

Solenoid Design and Applications. *I. Gebel*, Soreng, Products Corporation

Electronic Surface Unit Control. *C. J. Holtkamp*, Westinghouse Electric Corporation

Further Plans Made for the Summer and Pacific General Meeting

PLANS FOR THE 1956 Summer and Pacific General Meeting at the Fairmont Hotel in San Francisco, June 25–29, are nearing completion. A full and diversified program seems assured. A variety of technical programs and field trips, plus entertainment and sports programs have been planned, and a full program for the ladies is included. In addition, northern California offers excellent vacation opportunities. A San Francisco travel agency has been appointed official travel agent to arrange a gala post meeting tour to Hawaii at attractive rates.

Field Trips

Several interesting inspection trips to industrial installations and educational institutions in the Bay Area are planned. The highlight of the inspection trips will be a boat trip through San Francisco Bay, San Pablo Bay, and Suisun Bay to the Pacific Gas and Electric Company's Pittsburgh

Courtesy University of California

A TRIP to the Radiation Laboratory of the University of California, including the Bevatron Building (lower center), is among the trips planned for the Summer and Pacific General Meeting.

ASSEMBLING a 60,000-kw turbine at Westinghouse Electric Corporation's Sunnyvale plant. An inspection trip to this plant is planned during the Summer and Pacific General Meeting.

Steam Plant. This trip will offer an unparalleled view of the bay and bridges, and points of industrial and historical interest along the way.

Ladies Program

The Ladies Entertainment Committee has arranged a coffee hour each morning, Monday through Thursday, at 9 a.m. On Sunday, June 24, there will be a Welcome Tea at the Fairmont Hotel from 4 to 5 p.m. Tuesday will be highlighted by a luncheon and fashion show at the Palace Hotel. Wednesday will feature a tour of the San Francisco peninsula and Roth Gardens. On Thursday, a shopping tour of Chinatown is planned. Friday, the ladies will join the men for the boat tour through the Bay.

Sports

Since Salmon fishing is generally excellent in this area during June, the committee is planning an AIEE Salmon Derby. Preparation is absolutly minimum as all that is needed is some warm loafing garb; everything else will be provided.

The cabin power boats, accommodating 6 to 10 persons each, are clean and comfortable. Boat skippers are very helpful and will be glad to give full instructions to the lesser experienced on how to fish. Fishing tackle and bait, as well as a box lunch, will be furnished for each person.

Plan now for this big AIEE Salmon Derby. It would be most helpful to the Committee if those interested would indicate their intention to participate in the Derby on their advance registration cards.

Lake Merced Golf and Country Club in San Francisco, beautifully situated with fairly level terrain, will be host to all meeting registrants for a tournament commencing at 12 noon on Tuesday, June 26. This contest will be open to all players, and several beautiful and valuable prizes will be awarded. Caddies and carts will be available. The Committee will be as helpful as possible in arranging for equipment, if players cannot bring their own clubs.

The women of the meeting are cordially invited to play the same course early Tuesday morning, June 26. It is hoped that a sufficient number will play to warrant a tournament with prizes for the ladies.

Any golfers desiring noncompetitive golf on days other than June 26 should consult the Committee at the Sports Desk.

Hotel Reservations

Rooms have been set aside for members and their guests at these hotels: Fairmont (headquarters hotel), $10.50–19; Mark Hopkins, $10–20; Huntington, $8–15; Chancellor, $5.75–8.75; Plaza, $9–15; Hillcrest, $4–5.50; Alexander Hamilton (twin beds only), $10–12; Canterbury, $8–10; Cartwright, $7–8; and Cecil, $5–8.50. Rooms will be available in nine other hotels, at prices of $6–10. Plans are under way to reserve rooms in motels in San Francisco. Write for reservations to AIEE Hotels Committee, Box 4588, San Francisco 1, Calif. Include your preference as to hotels, type of accommodations, price range, date of arrival, and mention the 1956 Summer and Pacific General Meeting. Reservations for motels should be so indicated. All reservations will be handled on a first-come first-served basis.

Technical Sessions

At this point in the planning of the technical program 63 sessions are being organized by the technical committees of the Institute.

In the Power Division, sessions will be held on the subjects of protective devices, relays, substations, transmission and distribution, rotating machinery, transformers, system engineering, switchgear, carrier current, power generation, and insulated conductors.

Among the sessions being organized in the Science and Electronics Division are those on instruments and measurements, solid-state devices, magnetic amplifiers, electronics, basic sciences, metallic rectifiers, and computing devices.

In the Industry Division, sessions are in progress by the Committees on General Industry Applications, Industrial Power Systems, Mining and Metal Industry, Industrial Power Rectifiers, Chemical Industry, and Feedback Control Systems.

In the Communication Division, the following committees have been planning sessions: Communication Theory, Telegraph Systems, Communication Switching Systems, Wire Communication Systems, Television and Aural Broadcasting, and Radio Communication Systems.

In the General Applications Division, sessions are scheduled on domestic and commercial applications, and land transportation. In addition, the following general committees of the Institute are sponsoring technical sessions or conferences: Sections, Research, Management, and Safety.

Bimonthly Publications

The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Top Executives Address 1956 Electronic Components Symposium

Foreign and American industry executives and government authorities will join together in making a comprehensive review of accomplishments in the electronic component field and in surveying its future trends during the 1956 Electronic Components Symposium which is being held in Washington, D. C., May 1–3.

The chairman of this year's symposium is A. W. Rogers, U. S. Army Signal Corps, Fort Monmouth, N. J., and the technical program chairman is P. S. Darnell, Bell Telephone Laboratories, Inc., Whippany, N. J. This is the seventh in a series of annual technical meetings devoted to electronic components.

The theme of this year's three-day technical meeting is "Components—Accomplishments and Trends." The symposium is sponsored jointly by AIEE, Radio-Electronics-Television Manufacturers Association, Institute of Radio Engineers, and the West Coast Electronic Manufacturers Association with the active participation of the Department of Defense and the National Bureau of Standards.

The program is divided into seven sections including an evening session devoted to electron tubes and solid-state devices. Opening remarks by the chairman will precede a talk on "Future Demands on Component Design" presented by Captain W. I. Bull, USN, associate chief, Bureau of Ships for Electronics. This paper will be followed in the opening session by a discussion of broad reliability problems, international developments, and future trends in the electronic components field.

The evening Session V, electron tubes and solid-state devices, will be held on Wednesday, May 2, under Chairman J. S. E. Griemsmann, Polytechnic Institute of Brooklyn, and will feature papers on the state of the art of semiconductor devices, high power silicon transistors, current trends, cathode ray tube development and design, and other electron tube applications.

Registration for the three-day meeting will be $2.50 if paid in advance and $3.50 if paid at the door. The published proceedings containing complete transcripts of all papers will be available for $4.50 if advance payment is made. The post-symposium price for the proceedings will be $5. Advance

registrations should be directed to A. E. Zdobysz, Treasurer, 1956 Electronic Components Symposium, P. O. Box 1111, Alexandria, Va.

The complete program for the 1956 Electronic Components Symposium appeared in the April 1956 issue of *Electrical Engineering*, p. 385.

Transistor Circuits Conference Expands Program

The 1956 Transistor Circuits Conference was held in Philadelphia, Pa., February 16–17, in the Irvine Auditorium and the University Museum Auditorium, under the joint auspices of AIEE, Institute of Radio Engineers (IRE), and the University of Pennsylvania. A total of 1,164 people attended the conference which was nearly 48 per cent more than in 1955. Since the first conference held in 1954, attendance at the conference has doubled.

This year's conference program had one change from that offered in past years: two sessions consisting of two invited papers of tutorial lectures were given on the first day of the conference. The reception given the tutorial sessions could be measured by the fact that about equal attendance was present in each auditorium throughout the parallel sessions. Only contributed papers were heard in single sessions on Friday.

The attendance at the conference included representatives from 30 states and a number of people from outside the United States including 13 from Canada, 2 from England, 1 from Japan, and 1 from Sweden. Altogether, 19 technical papers were delivered in addition to the 4 tutorial papers. The conference committee is not planning to publish proceedings of this conference; however, the authors in many cases do plan to offer their papers to various technical journals for publication.

The opening session of the conference offered an address by G. W. Haller, chairman of the conference and director of the laboratories department, Electronics Division, General Electric Company, Syracuse, N. Y. In addition, $100 worth of library text books relating to transistors was presented to the University by D. G. Fink, chairman of the 1955 Transistor Circuits Conference and one of the directors of research of the Philco Corporation. These books were accepted by Dr. J. G. Brainerd, professor of electrical engineering at the Moore School of Electrical Engineering of the University of Pennsylvania.

There remain additional copies of the conference program which contains the abstracts for all of the contributed papers. Since no proceedings are to be published, persons desiring copies of these abstracts may obtain them by writing to J. D. Chapline, c/o Research Division, Philco Corporation, "C" and Tioga Streets, Philadelphia 34, Pa.

Fifth Scintillation Counter Symposium, Washington, D. C.

Over 300 scientists and engineers attended the Fifth Scintillation Counter Symposium, held at the Shoreham Hotel, Washington, D. C., February 28–29, 1956. The Symposium was sponsored jointly by the AIEE, the Institute of Radio Engineers Professional Group on Nuclear Sciences, the Atomic Energy Commission, and the National Bureau of Standards.

Presiding at the technical sessions were G. A. Morton of Radio Corporation of America (RCA) Laboratories; R. K. Swank of Argonne National Laboratory; P. R. Bell of Oak Ridge National Laboratory; and F. Reines of Los Alamos Scientific Laboratory.

Invited 30-minute papers included "Review of the Present Situation in Multi-Channel Analyzers" by W. A. Higinbotham of Brookhaven National Laboratory; "Multi-alkali Cathode" by A. H. Sommer of RCA Laboratories; "Present Techniques and Theory of Fast Coincidence Experiments" by Zoltan Bay of the National Bureau of Standards; "Gaseous Scintillation" by Charles Eggler and C. M. Huddleston of Argonne National Laboratory; "Alkali Halide Scintillators" by Wesley Van Sciver of Levinthal Electronic Products, Inc.; "Use of Heavy Metals in Scintillating Solutions" by H. E. Kallmann of New York University; "High Energy Gamma Spectroscopy" by C. A. Swartz of Brookhaven; "Low Energy Gamma Scintillation Spectrometers" by C. J. Borkowski of Oak Ridge; "Neutron Scintillation Counters" by C. O. Muehlhause of Brookhaven; "An Analysis of the Background Radiation Detected by NaI Crystals" by C. E. Miller, L. D. Marinelli, J. E. Rose, and R. E. Rowland of Argonne; "In Vivo Gamma Measurements at Very Low Levels with 4-Pi Liquid Scintillation Detectors" by E. C. Anderson of Los Alamos; and "The Physics of Solid-State Light Amplifiers" by D. A. Cusano of the General Electric Company. In addition, 16 contributed 10-minute papers were presented.

Mr. Morton presided at an evening panel discussion on the subject of scintillation counting problems and international developments.

Proceedings of the Symposium will be published in a volume of Transactions of the Professional Group on Nuclear Sciences of the Institute of Radio Engineers.

Annual Meeting

The annual meeting of the American Institute of Electrical Engineers will be held in San Francisco, Calif., at 2 p.m., Monday, June 25, 1956, during the Summer and Pacific General Meeting.

At this meeting, the annual report of the Board of Directors and the reports of the Committee of Tellers on the ballots case for the election of officers and for the proposed amendments to the AIEE Constitution will be presented. The Lamme Medal will be presented to Clinton R. Hanna (AM '24, M '39, F '44).

Such other business, if any, as may properly come before the annual meeting may be considered.

Signed N. S. HIBSHMAN
Secretary

SOME OF THE MEMBERS responsible for the 1956 Transistor Circuits Conference: (*left to right, front*) H. J. Woll, Radio Corporation of America, chairman of the Program Committee; G. L. Haller, General Electric Company, chairman of the National Committee; W. P. West, Leeds and Northrup, chairman of the Local Arrangements Committee; C. W. Hargens, Franklin Institute Laboratories, chairman of the Registration Subcommittee; (*left to right, rear*) A. P. Stern, General Electric Company, secretary of National Committee; H. E. Tompkins, Burroughs Corporation, IRE representative, Philadelphia PGCT and a member of the Program Committee; J. D. Chapline, Philco Corporation, chairman of the National Publicity Committee; I. L. Auerbach, Burroughs Corporation, treasurer of the National Committee; and W. J. Popowsky, Minneapolis-Honeywell Regulator Company, chairman of the Luncheon Arrangements Subcommittee.

Annual Ladies Night Held by Providence Section

The Providence (R.I.) Section of the AIEE was host on March 13, 1956, to the wives of its members at the annual "Ladies Night" program in the Commodore Room of Johnson's Hummocks Grille. About 75 members and guests heard Prof. C. H. Smiley of Brown University speak on his recent expedition to Thailand.

One of the highlights of the evening was the presentation of prizes to the winners of the Technical Papers Contest which was sponsored by the section on February 10. First prize of $50 and a certificate was awarded to P. S. Shelton for his paper, "12.47 Kv Electrical Distribution in Southern New England." Second prize of $30 and certificate went to Lawrence Urban for a paper entitled "Installation of Automatic Current

FIRST PRIZE in technical papers contest is presented to P. S. Shelton (*center*) by E. M. Adams (*left*), chairman of the AIEE Providence Section, as Prof. C. H. Smiley (*right*), of Brown University, observes the presentation of the award.

Courtesy Miriam W. Marcy

Controlled Shunt Capacitors on Power Distribution Circuits." A. L. Marshall was awarded third prize of $20 and a certificate for his paper, "Ice Melting Procedure on the 69 Kv System of The Narragansett Electric Company." The prizes were presented by E. M. Adams, chairman of the Section, and J. R. Toomey, chairman of the Technical Papers Committee. J. D. Hersey was chairman of the Program Committee in charge of the evening's festivities.

Design Engineering Show Will Be Held in Philadelphia, Pa.

More than 12,000 visitors, representing every major industry, are expected to see exhibits valued at $2 million at the first Design Engineering Show May 14–17, at Convention Hall, Philadelphia, Pa. The event will be produced by the exposition management firm of Clapp and Poliak, Inc., New York, N. Y.

Engineers, responsible for designing products used in the home and by industry, will see thousands of components and materials which go into the making of end products. The exposition, expected to have far-reaching effects on all types of products, represents the first time design engineers in one industry will be able to see under one roof the design developments of all other industries.

On display will be electrical and mechanical components, metallic and nonmetallic materials, fasteners, finishes and coatings, hydraulic and pneumatic components, shapes and forms, and accessories.

To accompany the exhibits, the machine design division of the American Society of Mechanical Engineers will sponsor a four-day conference on design engineering.

Topics at the conference will include cost reduction through product design, finding and training design engineers, selecting materials, problems arising from the trend toward miniaturization, rewards for employee inventions, and legal rights of employees in inventions.

Advance registration cards may be obtained from Clapp and Poliak, Inc., 341 Madison Ave., New York 17, N. Y.

Pittsburgh Nuclear Activities Council Organized

In order to keep abreast of developments in nuclear science and technology and to assist in the development of this field in the Pittsburgh area, a Nuclear Activities Council has been organized. The membership is composed of representatives from 16 technical societies active in the district. C. L. Wagner, of Westinghouse Electric Corporation, will represent the Pittsburgh Section of AIEE, with W. H. Osterle, of West Penn Power Company, as the alternate.

The Council has held two meetings and the Constitution and By-laws have been prepared and submitted for approval. The Council will co-ordinate the activities of member societies, investigate the needs for industrial training courses, inventory the area's institutional facilities for nuclear research, and provide a central nuclear information agency. In addition, it has planned to sponsor a series of inter-society lecture courses on nuclear science and act to assist member societies in obtaining qualified speakers in the field.

National Power Show Returns to New York City

In the two months following the announcement of the return of the National Power Show to New York, after a four-year absence, nearly 200 leading companies have shown keen interest by engaging exhibition space. Officially known as the 22nd National Exposition of Power and Mechanical Engineering, the display is scheduled for November 26–30 under the auspices of the American Society of Mechanical Engineers (ASME) in conjunction with the Society's 76th annual meeting. As before, it will be under the management of the International Exposition Company.

Displays will feature the newest equipment in the vast power field and mechanical engineering applications. An added attraction this year is an enlarged atomic power section, including displays by many pioneering companies. Supporting these tangible evidences of progress in nuclear engineering, will be the important technical sessions of the ASME Nuclear Engineering Division, as well as the National Industrial Conference Board's fifth annual "Atomic Energy in Industry" conference, which will be held at the same time.

The exposition will be held in the recently completed New York Coliseum, most modern exposition hall in America, whose mid-city location is readily accessible by all means of transportation.

Two Engineers Are Honored By American Standards Association

C. W. Franklin (M '24, F '44) and A. C. Muir (AM '25, M '39), were honored recently by the American Standards Association (ASA) in recognition of their work in the development of American Standards. The recipients of the service scrolls are members of the Standards Council which is responsible for the technical program of the American Standards Association.

C. W. Franklin, Consolidated Edison Company of New York, represents the Electric Light and Power Group on the Standards Council. This group is composed of the Association of Edison Illuminating Companies and the Edison Electric Institute. A. C. Muir, Berwind-White Coal Mining Company, Philadelphia, Pa., represents the AIEE as a Director.

The citations read, "The American Standards Association presents this certificate in recognition of contributions to the establishment of voluntary standards and in appreciation of sound advice and devotion of energy to the furtherance of the standards movement as a means of advancing the national economy."

Mr. Muir and Mr. Franklin are among the representatives of many national technical societies, trade associations, and consumer groups holding membership on the Standards Council.

The Standards Council is the judicial body of ASA, which acts in the public interest by assuring that all standards projects are national in scope and representative of all groups concerned with the subjects of proposed standards.

The Standards Council has approved 1,500 American Standards in a wide variety of fields: civil engineering and construction, safety, mechanical engineering, electrical engineering, photography and motion pictures, chemicals, mining and metallurgy, rubber, drawings, textiles, gas-burning appliances, and many others.

The American Standards Association is the national clearinghouse for voluntary industrial and consumer standards. It is a federation of 115 trade associations, technical societies, and public interest groups. There are also 2,300 companies affiliated as members.

"Engineer" and "Technician" Defined at Engineering Conferences

The following is a definition of "engineer" and "technician" adopted by the Commonwealth Engineering Conference, 1954, and by the Conference of Engineering Societies of Western Europe and the United States, 1955.

"A professional engineer is competent by virtue of his fundamental education and training to apply the scientific method and outlook to the analysis and solution of engineering problems. He is able to assume personal responsibility for the development and application of engineering science and knowledge, notably in research, designing, construction, manufacturing, superintending, managing, and in the education of the engineer. His work is predominantly intellectual and varied, and not of a routine mental or physical character. It requires the exercise of original thought and judgment, and the ability to supervise the technical and administrative work of others.

"An engineering technician is one who can apply in a responsible manner proved techniques which are commonly understood by those who are expert in a branch of engineering or those techniques specially prescribed by professional engineers."

The report goes on to describe some of the duties typical of the work carried out by engineering technicians, such as: ". . . working on design and development of engineering plant and structure; erecting and commissioning of engineering equipment and structures; engineering drawing; estimating inspecting, and testing engineering construction and equipment; use of surveying instruments; operating, maintaining, and repairing engineering machinery, plant, and engineering services and locating defects therein . . ."

This was quoted from the record of Parliamentary Debates of the British House of Commons, volume 554, number 33, Columns 590 and 591, July 21, 1955.

Seminar To Be Held on Industrial Standardization

A Gaillard Seminar on industrial standardization will be held June 18–22, 1956, in New York, N. Y. There will be two conferences each day, Monday through Friday, mornings from 9:30 to 12, afternoons from 1:30 to 4.

Six conferences will be devoted entirely to organization and procedure of standardization work in an individual company. The other four will deal with the principles and practical applications of organized standardization, both from the technical and the managerial viewpoint. Round-table discussion will present opportunity for the conferees to bring up problems of special interest to their own work.

Dr. Gaillard, a management counsel specializing in advice on standardization problems, will also offer a new service, the Company Standards Seminar, following a request from industry. Company managements now may arrange to have a seminar held at their headquarters attended by key men representing various departments, divisions, plants, or other administrative units of the sponsor company. This special Company Standards Seminar will make it possible to have a number of men trained as a group and to concentrate on discussion of the company's particular problems.

Further information about registration for the June 1956, Gaillard Seminar, or special arrangements for a Company Standards Seminar, may be obtained from Dr. John Gaillard, 400 West 118 St., New York 27, N. Y.

Engineers of Several Nations To Address ASCE Convention

During the national Spring convention of the American Society of Civil Engineers (ASCE), to be held in Knoxville, Tenn., June 4–8, Tennessee Valley Authority (TVA) experiences and the future of multipurpose river development will be discussed by engineers of TVA, the Bureau of Reclamation, and others.

A symposium on arch dams will bring forward papers by authorities representing France, Italy, Japan, Portugal, and the United States. Other technical sessions will concentrate on design progress, developments, and methods in reinforced concrete design and construction. Many phases of civil engineering will be covered in a total of 27 technical sessions.

Dr. E. W. Engstrom Honored by Swedish Engineers

E. W. Engstrom (F '49), senior executive vice-president, Radio Corporation of America (RCA), has been elected a Foreign Member of the Royal Swedish Academy of Engineering Sciences.

The announcement followed the presentation to Dr. Engstrom of the John Ericsson Medal by the American Society of Swedish Engineers at its annual dinner in New York on February 11. The medal was presented for ". . . distinguished achievements in science and engineering." Established to honor the Swedish-American engineer among whose many outstanding developments was the *Monitor* of Civil War fame, the John Ericsson Medal is given at 2-year intervals, alternating between a person of Swedish descent in the United States and a citizen of Sweden.

F. W. Alexanderson (AM '04, M '13, F '20), pioneer in radio and electrical engineering, presented the medal, praising Dr. Engstrom for "ability and creativeness" and for his leadership of important team research in the field of electronics.

"It is rare that outstanding scientific and engineering ability is combined with outstanding executive ability," said Dr. Alexanderson, "but now we find Dr. Engstrom a senior executive vice-president and a director of RCA, responsible for research, engineering and manufacturing."

In an address at the dinner, Dr. Engstrom called for efforts by the United States "to be first and to build an impregnable strength" in intercontinental missiles in order to deter aggression.

Future AIEE Meetings

AIEE-IRE Electronic Material and Component Symposium*
Washington, D. C.
May 1–3, 1956

North Eastern District Meeting*
Sheraton Hotel, Rochester, N. Y.
May 2–4, 1956

Seventh Annual Appliance Technical Conference*
Wisconsin Hotel, Milwaukee, Wisc.
May 14–15, 1956

Summer and Pacific General Meeting*
San Francisco, Calif.
June 25–29, 1956

AIEE-IRE-ISA Telemetering Conference
Ambassador Hotel, Los Angeles, Calif.
August 20–21, 1956
(*Final date for †TP—May 20, ‡CP Syn.—June 5, CPMs—June 15*)

Fall General Meeting
Morrison Hotel, Chicago, Ill.
October 1–5, 1956
(*Final date for †TP—July 3, ‡CP Syn.—July 19, CPMs—July 27*)

Winter General Meeting
Hotel Statler, New York, N. Y.
January 21–25, 1957
(*Final date for †TP—Oct. 24, ‡CP Syn.—Nov. 8, CPMs*—Nov. *16*)

North Eastern District Meeting
Pittsfield, Mass.
May 1–3, 1957
(*Final date for †TP—Feb. 1, §DP Syn.—Feb. 15, DPMs—Feb. 25*)

Middle Eastern District Meeting
Dayton, Ohio
May 7–9, 1957
(*Final date for †TP—Feb. 7, §DP Syn.—Feb. 22, DPMs—March 5*)

Summer General Meeting
Montreal, Que., Can.
June 24–28, 1957
(*Final date for †TP—March 26, ‡CP Syn.—April 11, CPMs—April 19*)

Pacific General Meeting
Yakima, Wash.
Aug. 28–30, 1957
(*Final date for †TP—May 31, ‡CP Syn.—June 14, CPMs—June 25*)

Fall General Meeting
Chicago, Ill.
Oct. 7–11, 1957
(*Final date for †TP—July 10, ‡CP Syn.—July 25, CPMs—Aug. 2*)

Winter General Meeting
Hotel Statler, New York, N. Y.
Jan. 20–24, 1958
(*Final date for †TP—Oct. 23, ‡CP Syn.—Nov. 7, CPMs—Nov. 15*)

*Final date for submitting papers—closed
†TP—Transactions paper
‡CPSyn.—Conference Synopsis
CPMs—Conference Manuscript
(The CPSyn. date is 10 days before the CPMs date)
§DPSyn.—District Synopsis
DPMs—District Manuscript
(The DPSyn. date is 10 days before the DPMs date)

"We must be determined that our strength shall be kept as a deterrent to aggression, that our strength shall be a means to keep the peace," he said.

Speaking of the objectives of scientific research and engineering Dr. Engstrom said that the creative instinct in people must be encouraged today more than it has been ever before.

"We need to be certain that our uses of the results of science are toward objective ends which are in keeping with the divine purpose for our lives," he added. "We need to do this so that we may continue to be free men, so that science itself will not become the master of men, and so that a few using the tools of science will not enslave others."

New Silicon Rectifier for Aircraft Reported

The development of a new silicon power rectifier for aircraft, capable of operating at high ambient temperatures and high altitude, and opening the way for other applications, was announced at the AIEE South West District Meeting, Dallas, Tex., by H. B. James, Westinghouse Electric Corp., Lima, Ohio.

Mr. James stated that the new device is more than able to accomplish the goal of operating at ambient levels of 120 C, but there must be more work in the field before 200 C at pressure-altitudes as high as 70,000 feet can be achieved.

It was observed that ever since large quantities of alternating current have been generated on aircraft there has been a need for suitable conversion devices to provide necessary direct current. Selenium transformer rectifiers have been used satisfactorily for this purpose for 10 years, but it was not until the silicon power rectifier was developed that the transformer rectifier was able to catch up with the progress of many of the other parts of the electrical system.

It was further developed that the general requirements for conversion equipment on aircraft are no different today than they were for the past decade, except that in every single category they are more severe. Airplanes today fly faster, higher, and under more extreme environmental conditions than ever before. In order to perform their complex missions, the performance of the various systems aboard the aircraft must extend themselves in all respects, and due to the high premium placed on size and weight, the equipment must be designed carefully to save space and minimize weight.

At the time the paper was written, tests and development were still in progress and inasmuch as improvements are continually being made to both components and the over-all design, it can be definitely stated that tests which had been conducted up to the time immediately preceding the meeting had given proof that the design of this new transformer-rectifier will satisfy the necessary requirements as stated in the paper.

Mr. James continued by saying operating experience with Magamp generator regulators leads one to expect the same fine performance from converters which embody the same type of design criteria. The addition of the silicon power rectifier to the components available for the design engineer opens the field for applications of d-c power supplies which have not been possible before.

He concluded that new developments in transistor devices and new circuit concepts will be integrated into the regulated transformer-rectifiers as they become available.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

International Instrument-Automation Conference To Be Held

The 11th International Instrument-Automation Conference and Exhibit will take place September 17–21 under the auspices of the Instrument Society of America, which is an international technical organization devoted to advancing automation through the design and use of measurement and control instruments. The exhibits will be housed in the new Coliseum, 59th Street and Broadway, New York, N. Y. The technical sessions, clinics, workshops, special meetings, and banquets will take place in rooms of the Coliseum, Columbia University, and the Hotels Statler and New Yorker.

An estimated 30,000 engineers and scientists, are expected to register for the conference.

Exhibit space in the Coliseum is now almost completely under contract. Close to 300 different companies will show new products ranging from compact desktop digital computers to remote controllers for guided missiles. A special display area will be given over to special projects in measurements and control now on the workbenches of eight leading universities. Foreign displays will include samples from Japan's fast-growing instrument industry as well as booths operated by English, German, Netherlands, Italian, and French firms.

Washington Award Presented to R. E. Wilson

R. E. Wilson, chairman of the board, Standard Oil Company of Indiana, has been elected to be the recipient of the Washington Award for 1956.

The presentation will be made at a joint dinner meeting of the participating societies on Tuesday evening, May 1, at the Furniture Club of America, 667 North McClurg Court, Chicago, Ill.

The Washington Award was established in 1916 by Past President Alvord of the Western Society of Engineers" . . . to be annually presented to an engineer whose work in some special instance, or whose services in general have been noteworthy for their merit in promoting the public good." The award is made annually by the Washington Award Commission, composed of nine representatives of the Western Society of Engineers and two each from AIEE, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, and the American Society of Mechanical Engineers.

Fortescue Fellowship Award Announced for 1956–57

The Charles LeGeyt Fortescue Fellowship Committee of the Institute has awarded two fellowships for graduate study in electrical engineering during the academic year 1956–57 to Daniel F. Fox, Jr., of Pittsburgh, Pa., and Kenneth F. Steffan of Rollo, Mo.

Complete details will be published in the June issue of *Electrical Engineering*.

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until May 31. Duplicate double-spaced typewritten copies of each discussion should be sent to Edward C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th Street, New York 18, N. Y., on or before May 31.

56-91 **Magnetic Logic Circuits for Industrial Control Systems.** *W. G. Evans, W. G. Hall, R. I. Van Nice*

56-94 **Transistor Power Amplifiers with Switched Mode of Operation.** *A. G. Milnes*

56-105 **An Air-Cleaning Blower for Ventilating Traction Equipment.** *J. J. Gallagher*

56-109 **Influence of Atmospheric Water Vapor on High-Current D-C Arcs.** *R. H. Benner, II, T. B. Jones*

56-236 **Heat as a Means of Air Purification.** *J. C. Beckett, C. E. Clifton*

Preprints may be purchased at 40¢ each to members, 80¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th Street, New York 38, N. Y.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Communication Division

Committee on Communication Switching Systems (William Keister, *Chairman;* Eric Brooke, *Vice-Chairman;* D. L. Solomon, *Secretary*). The Committee held a luncheon get-together during the recent Winter General Meeting in New York City. Sixteen members of the Committee, from points as far apart as Dallas, Tex., and Montreal, Que., Can., met to discuss current plans and future activities.

The Committee intends to recommend two sessions at each future Summer Meeting, with three or four papers at each session. Continuous development in improved switching components (wire spring and other relays, transistors, etc.), as well as the advent of several new switching systems (line concentrators, tandem centers, etc.) will provide a satisfactory number of papers of wide interest to communications engineers at the various seasonal and regional meetings.

Two promising subjects for future sessions appear to be line concentrators, wherein switching units at a telephone central office and at a remote point enable numerous subscribers to enjoy satisfactory telephone service without heavy investment in expensive outside lines, and the advent of partial or full electronic switching systems. The Bell System has announced its forthcoming trial electronic exchange in Illinois and several telephone manufacturers are known to be busily engaged in similar developments. The Committee plans to devote at least one full session to each of these fields.

In addition, it is planned to present at least one paper on current foreign communication switching developments at each of the future general meetings. It is believed that developments overseas are always of considerable interest to American engineers and that much worthwhile information can be derived from first-hand reports by prominent switching engineers from abroad.

Committee on Wire Communications Systems (H. R. Huntley, *Chairman;* L. R. Montfort, *Vice-Chairman;* D. T. Osgood, *Secretary*). The Wire Communications Systems Committee, in conjunction with the other committees in the Communication Division, is making plans for a series of sessions on maintenance of electronic communications equipment. Inasmuch as this subject has been receiving increasing interest in recent years, it is felt that an opportunity should be provided for the various sections of the communications industry to present their views and benefit from those of others. Emphasis in the communications field appears at present to be largely on the short haul, light route types of carrier and radio circuits, and the paramount consideration is, therefore, low costs. However, low first costs may often mean a sacrifice in performance or increased maintenance expense. The conference will enable both manufacturers and users of communications equipment to exchange ideas on how to handle these problems.

It is planned to hold the first two of the proposed sessions in conjunction with the Fall General Meeting at Chicago, Ill., on the last day of the convention. This time was chosen in order to obtain the widest possible participation. Chicago is centrally located, and many of the expected participants will be present for the General Meeting. Furthermore, it will be just prior to the U. S. Independent Telephone Association (USITA) convention, which will be held in the same city.

All committees of the Communication Division as well as the Carrier Current Committee are being asked to participate. Members of USITA and Association of American Railroads (AAR) are also expected to be interested.

Papers for presentation at these conferences will be primarily of the conference type in order to afford the widest possible latitude to the authors and so they may be written in such a way as to provoke discussion. If sufficient interest is shown at Chicago, it may be desirable to initiate a Special Technical Conference at a later date.

Industry Division

Committee on Chemical Industry (J. Z. Linsenmeyer, *Chairman;* F. S. Glaza, *Vice-Chairman;* E. H. Browning, *Secretary*). The Committee on Chemical Industry has found the Winter General Meeting to be most popular with its members. The last business meeting was attended by 26 electrical engineers connected with the chemical industry, representing 17 companies located in 21 different cities. Four technical sessions sponsored by the various subcommittees discussed a wide range of subjects: electric furnace problems, transformers, and control; chemical process applications of gas turbines, automatic process control, inspection of new construction, and titanium production; and galvanic fuel cells, nuclear batteries and cathodic protection techniques. The symposium on maintenance of large rectifier conversion substations for electrolytic plants drew an overflow crowd with broad participation in the discussion.

Technical sessions at the South West District Meeting in Dallas, Tex., discussed problems of chemical plant power supply, distribution, and control with related maintenance problems under conditions of chemical contamination and hazard due to presence of flammables. The Pacific Coast Subcommittee is organizing technical sessions bearing on problems similar to those existing on the Gulf Coast. Papers on power sources for electrolytic applications, power supply, and cathodic protection will be presented by authors under sponsorship of this newly formed subcommittee at the coming Summer and Pacific General Meeting in San Francisco, Calif. This opportunity to discuss mutual problems should draw wide interest from engineers who find meetings on the eastern seaboard too difficult to attend.

Committee on Electric Heating (W. C. Rudd, *Chairman;* F. T. Chesnut, *Vice-Chairman;* E. J. Bates, *Secretary*). This committee at its last meeting agreed to hold a two-day Electric Heating Conference in the Spring of 1957. Radiant, furnace, induction, and dielctric heating will be covered by some 16 papers. Plans are now being made for this event.

The Subcommittee on Induction and Dielectric Heating is, at present, very active in assembling radio interference data from high frequency heating equipment, in order to assist the Federal Communications Commission in writing the revised regulations for this type of industrial equipment.

The Data Subcommittee and the Radiant Heating Subcommittee are assisting in the planning for the coming Conference.

Power Division

Committee on Rotating Machinery (M. L. Schmidt, *Chairman;* L. O. Dorftman, *Vice-Chairman;* F. T. Carlson, *Secretary*). The Induction Machinery Subcommittee in its efforts toward improvement in the Art and Science of Induction Machinery design has been making a study of the application of digital computors to induction motor design. The committee feels that this work will enable a more thorough study of stray losses and analysis of motor performance of the part-winding start type. It is hoped that it will promote a better understanding of, and ways to reduce, motor noise.

One of the new developments in the induction motor field, brought about largely through developments in atomic energy applications, has been the "canned" type of pump motors. This has presented new design problems which require new treatment.

A joint effort through the Relay Committee has been under way to provide important motor protection and this undoubtedly will require considerable study and promote much discussion.

Plans are also under way for an Induction Machinery Application Guide. Vertical pump motor applications have indicated that further work must be done, particularly in the area of satisfactory vibration limits of the combined unit. This matter will receive further study.

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The D-C Machinery Subcommittee has been asked to prepare a proposed Guide for Operation and Maintenance of Turbine Generator Exciters as a companion Guide for the Operation and Maintenance of Turbine Generators. There are indications that this may expand into a broader task involving other committees if the proposed Guide is broadened to cover Excitation Systems. An alternate would be more than one Guide covering various aspects of the subject under appropriate committees.

A working group of this Subcommittee has just completed revision of AIEE Test Code 501 for D-C Machines. This has been referred to the Test Codes and Standards Subcommittee for action. Another working group has been drafting a Guide for Short Circuit Calculations. This Guide was approved by the D-C Subcommittee at the Winter Meeting and it will be referred to the Rotating Machinery Committee for further action.

The Insulation Subcommittee has been active in formulating a Proposed Test Code for "Dielectric Acceptance Tests for New Rotating Machinery Rated 6,000 Volts and Above, Using D-C Test Voltages in Accordance with ASA C50." The Subcommittee will probably review AIEE Number 43, Recommended Practices for Testing Insulation Resistances of Rotating Machines, to determine if revision is desirable at this time.

The Test Procedure for Evaluation of Systems of Insulating Materials for Random-Wound Electrical Machinery was referred to the Rotating Machinery Committee for letter ballot.

The Synchronous Machinery Subcommittee Working Group on a proposed Guide for Operation and Maintenance of Turbine Generators is putting the Guide in final form for request for submission to letter ballot. This proposed Guide has required a great deal of effort on the part of the Working Group extending through the past two or three years.

The Subcommittee also has a task group formulating a complete revision of the Synchronous Machinery Test Code Number 503. This work is well along and should be completed in a few months.

There is one working group operating directly under the Committee on Rotating Machinery. This group which has been studying the measurement of rotating machinery noise has held several meetings and has reported progress.

Another task force under the Committee, known as the Per Unit Task Committee, is still trying to formulate definitions of per unit quantities that will satisfactorily meet requirements and be acceptable to various interested groups. Another meeting is planned in the near future and there seems to be some progress in arriving at acceptable definitions.

Committee on Substations (I. S. Mendenhall, *Chairman;* W. S. Scheering, *Vice-Chairman;* J. A. Smith, *Secretary*). The Committee on Substations is actively carrying on all of the projects which have been started.

One project, that of the Working Group on Location and Design of Distribution Substations in Residential Areas, was completed, and resulted in a paper that was presented at the 1956 Winter General Meeting.

The fifth draft of the proposed revision of American Standard for "Automatic Substation Control, Supervisory and Associated Telemetering Equipment," C37.2—1945, is out for ballot at the present time.

A new project "Voltage Gradients through the Earth under Fault Conditions" has been undertaken by the Committee and a working group is being formed to investigate this subject.

The West Coast Subcommittee is working on a technical program for the main Committee to be presented at the Summer General Meeting in San Francisco.

Committee on System Engineering (A. P. Hayward, *Chairman;* R. T. Purdy, *Vice-Chairman;* H. C. Otten, *Secretary*). The organization of this Committee now consists of Subcommittees on System Planning, System Economics, System Operations, System Controls, Applications of Probability Methods, and Computer Application. The work of the last two Subcommittees is conducted jointly with other committees. The work on Probability Methods is now in association with the Committee on Power Generation and that on Computer Application is tied-in with the Committee on Computing Devices.

The Subcommittee on System Planning has sponsored a report on system aspects of arc furnace loads which should be a useful guide for arranging supply of power for arc furnace loads. The Subcommittee on System Controls is completing a report summarizing the current status of tie line load and frequency control in 76 existing installations. Some 34 characteristics of these applications were investigated and the tabular summary affords a ready review of results obtained in operation. Liaison is being maintained with the Committee on Standards and the Committee on Telemetering.

Science and Electronics Division

Committee on Basic Sciences (W. R. LePage, *Chairman;* W. C. Dunlap, Jr., *Vice-Chairman;* S. B. Batdorf, *Secretary*). One of the main concerns of this Committee is to increase interest among the AIEE membership in the basic sciences. At the last meeting, a resolution was passed to the effect that the Basic Sciences Committee should provide a service in helping local sections to secure speakers on basic science topics for section meetings. In order to carry out this service, the chairman of the Committee will contact appropriate members of the Committee upon receipt of a request from a local section. In general, the committee membership will be used as a source of information as to the availability of speakers who may or may not be committee members.

Committee on Electronics, Subcommittee on Electron Tubes (D. S. Peck, *Chairman;* J. A. Goetz, *Vice-Chairman;* H. H. Wittenberg, *Secretary*). The work of the Subcommittee on Electron Tubes has been handled to a large extent through small working groups concerned with small vacuum tubes, cathode-ray tubes, gas tubes, photo tubes, mercury-pool cathode tubes, and power tubes. The mercury-pool cathode tube group had been particularly active in the preparation of the American Standard for "Pool Cathode Mercury-Arc Power Converters" with the Committee on Industrial Power Rectifiers. The working group on cathode ray tubes was recently instrumental in initiating joint AIEE-IRE consideration of standards for electrostatic storage tubes and the group on gas tubes has also been working jointly with IRE on revisions and additions to the American Standards Association "Definitions of Electrical Terms," pertaining to tubes.

Inasmuch as the area of definitions and test methods for tubes appears to be well covered at the present time, the Subcommittee has turned its attention to the problem of providing technical sessions at which tube development material will be presented for the benefit of those interested in the applications of electron tubes. Although practically all of the many conferences and meetings scheduled on electron tubes by other organizations are aimed at the development features or research problems connected with this field, there is very little outlet for a description of new tubes which are available for application, including their characteristics and design features. The Subcommittee plans to sponsor technical sessions each year covering this type of material. It is expected that these sessions would be of particular interest to industrial control and communications designers. Evidence of this interest was shown at the Winter Meeting at which about 75 people attended each of two such technical sessions. It is thought that with further promotion of these sessions during the year, a prospect which the Subcommittee is actively pursuing, an even wider audience will be reached.

AIEE FELLOWS ELECTED

Board of Directors Meeting, February 2, 1956

Wallace Lacy Chadwick (M '38), vice-president in charge of Engineering and Construction, Southern California Edison Company, Los Angeles, Calif., has been transferred to the grade of Fellow in the AIEE "...in recognition of his engineering and administrative achievements in directing design and construction in one of the nation's large power systems." He was born on December 4, 1897, in Loring, Kan., and he studied general engineering at the University of Redlands, Calif. Mr. Chadwick joined the Southern California Edison Company in 1922, serving as draftsman, division engineer, and transmission engineer. From 1931 to 1937, he was with the Metropolitan

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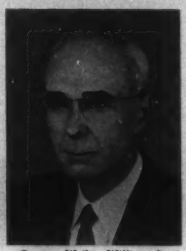
W. L. Chadwick

Chase News Photo

F. E. Keith



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F. G. Logan

T. D. Reimers

Water District of Southern California, following which he returned to the Southern California Edison Company as civil engineer, directing special studies and investigations. In 1939, he became chief civil engineer, directing general civil and construction engineering and, after 1942, directing mechanical and structural engineering as well. He was appointed manager of engineering in 1945, and vice-president in charge of engineering and construction in 1951. At present, he directs all technical activities of the company. The design and construction of many major company projects have been executed under his direction. Mr. Chadwick is a member of the American Society of Civil Engineers, the American Concrete Institute, the Pacific Coast Electrical Association, the Edison Electric Institute, the Association of Edison Illuminating Companies, the American Society of Mechanical Engineers (ASME), and he was president of the Los Angeles Engineering Council in 1947. On the occasion of the diamond anniversary of the ASME, Mr. Chadwick received a Man-of-the-Year citation from the Society's Southern California Section.

Fay Ellsworth Keith (AM '26, M '36), president, Keith Electric Construction Company, Des Moines, Iowa, has been transferred to the grade of Fellow in the AIEE "...for his contributions to the engineering management field of the electrical construction industry." Mr. Keith was born April 25, 1900 in Hartley, Iowa. He received his bachelor of science degree in electrical engineering from Iowa State College in 1923. After graduation he joined the General Electric Company, spending two years in the testing department, Schenectady, N. Y. In 1925, Mr. Keith joined the field force in the Chicago, Ill., office of this company. He became assistant superintendent of electrical installations in 1929, and held this position until 1944, when he organized and became president of Keith Electric. In his capacity as president, Mr. Keith supervises an engineering staff of five graduate electrical engineers, and holds the responsibility of both financial and engineering matters. Most of his time and that of his professional associates has been devoted to heavy electrical installation projects. These cover the installation of turbine generators, large power transformers, and switchgear in both the large and small power plants in Iowa, Minnesota, and Missouri. His company also does electrical work for large industrials of diverse character, such as packing plants, elevators, cement plants, and some large office buildings. Mr. Keith has done a great deal to promote the study of and improve the unit cost system of estimating, particularly with respect to heavy electric construction such as steel and concrete work, etc., on large and small outdoor substations. He has been distinguished by his broad approach to the labor-management problem, and has been successful in promoting several joint ventures of labor and management to promote the welfare of both in the electrical contracting industry. Mr. Keith has held several offices in the National Electrical Contractor Association.

Theodore Daniel Reimers (M '36), inside plant engineer, Consolidated Edison Company of New York, Inc., (ConEd), New York, N. Y., has been transferred to the grade of Fellow in the AIEE "...for his contributions to design of electrical production, transmission, and distribution systems for a highly concentrated metropolitan load area." Mr. Reimers was born in New York, N. Y., April 15, 1906. He attended Cornell University where he received an electrical engineering degree in 1927. Shortly afterwards, he started as a general tester with ConEd. He later transferred to the Outside Plant Bureau of the electrical engineering department where he soon became division engineer in charge of distribution equipment engineering. In the following years, he became electrical superintendent of Hudson Avenue generating station; division engineer, gas planning; assistant inside plant engineer; system planning engineer; and in December 1952, inside plant engineer in charge of electrical engineering design of the substations, gas and steam plants, and electrical generating stations on the ConEd system. The new Astoria Generating Station with two 190 mw units and a new generating unit at East River Station have been completed and two major area substations have been placed in service under his engineering guidance. Mr. Reimers is responsible for many new features in switching, bus design, and protection and novel arrangements of equipment, which have worked toward greater simplification, increased reliability, and lower capital cost. He is a member of the American Society for Testing Materials, and the International Conference on Large Electric High-Tension Systems (CIGRE). He has served on AIEE Transformers Committee (1947–53), and the Power Generation Committee (1953–56).

Frank Gordon Logan (AM '35, M '44), vice-president and general manager, Vickers Electric Division, Vickers, Inc., St. Louis, Mo., has been transferred to the grade of Fellow in the AIEE "...in recognition of pioneering work in the field of self saturating reactors." Mr. Logan was born in Chicago, Ill., December 8, 1901. He joined the Ward Leonard Electric Company, Mount Vernon, N. Y., in 1927 to handle their advertising; however, shortly thereafter he began to devote most of his time to the development of self saturating reactors as applied to various control devices. In 1937, he was named a director of the company. He was placed in charge of the regulator division in 1940, and was named vice-president in charge of research and development in 1944. His title was changed to vice-president in charge of all engineering activities in 1945. Mr. Logan resigned from the Ward Electric Company in 1948 in order to set up a new division of Vickers, Inc., a unit of the Sperry-Rand Corporation, where he was named vice-president and general manager. This new division was formed to develop and manufacture selenium power rectifiers, various types of equipment based upon self saturating reactor controls, and magnetic clutches and brakes. To date, Mr. Logan has had a total of 51 patents issued to him and 2 patents issued to him jointly with others. The majority of the patents concern devices or applications utilizing principles of self saturating reactors. A large number of these developments have come into being since Mr. Logan has been in executive or administrative positions. Mr. Logan is a civil member of the American Society of Naval Engineers.

Carl Edwin Smith (AM '32, M '38), consulting radio engineer, Carl E. Smith Consulting Radio Engineers, Cleveland, Ohio, has been transferred to the grade of Fellow in the AIEE "...for his contributions to broadcasting antenna design, military electronics, and electrical engineering education." Mr. Smith was born November 18, 1906 in Eldon, Iowa. He received his bachelor of science degree in electrical engineering from Iowa State College, Ames, Iowa, in 1930. He later attended Ohio State University where he received a master of science degree in 1932, and a professional degree in electrical engineering in 1936. Mr. Smith was engaged in general engineering consisting primarily of experimental research, design, and construction for the Union Broadcasting Company, Cleveland,

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C. E. Smith

H. V. Strandberg

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F. W. Tatum

J. D. Wood

Ohio, from 1933 to 1936. Following this, he became assistant chief engineer of radio stations WHK, WCLE, and W8XNT, Cleveland, Ohio, and then chief engineer of the first two stations mentioned. During World War II, Mr. Smith served as Assistant Chief, Operational Research Staff, Office of the Chief Signal Officer, U. S. Army. In his capacity as head of the training section, he gave advice in outlining training curricula and directing the preparation of the texts, "Radar Electronic Fundamentals" and "Radar System Fundamentals," used widely throughout both the Army and the Navy. Later, Mr. Smith's duties were broadened to head the training, equipment and propagation sections. In this capacity, he conducted research on the performance of short antennas which resulted in a large saving in the procurement of towers. In 1946, he became vice-president in charge of engineering for the United Broadcasting Company, Cleveland, Ohio. There, one of the more important contributions he inaugurated was the research and development work in the field of elliptical polarization, which has resulted in the modification of the standards of good engineering practice of the Federal Communications Commission and in the development and manufacture of a circularly polarized type of transmitting antenna for WHK-FM and WHKC-FM. In the same year, 1946, Mr. Smith became president of Cleveland Institute of Radio Electronics, Inc., Cleveland, Ohio. This Institute purchased the Smith Practical Radio Institute which Mr. Smith had founded in 1934 to meet the needs of a large number of radio and communication engineers that wanted a systematic presentation of engineering fundamentals in a practical home study course. In addition to extensive writing and editing of course material, he systematized over 15,000 directional antenna patterns and prepared a publication of this material. In 1953, Mr. Smith resigned from the United Broadcasting Company in order to devote full time to his consulting practice. He is a member of Institute of Radio Engineers, American Society for Engineering Education, Association of Federal Communications Consulting Engineers, and the Cleveland Engineering Society. Mr. Smith has served on the AIEE Radio Communications Systems Committee (1951–53), and the Television and Aural Broadcasting Systems Committee (1954–56).

Herbert Victor Strandberg (AM '27, M '37), chief engineer, Department of Lighting, City of Seattle, Wash., has been transferred to the grade of Fellow in the AIEE "...for his accomplishments in the development of a transmission and distribution system to supply electricity to a metropolitan area." Mr. Strandberg was born in Dawson, Yukon Territory, Can., December 28, 1902. He graduated from the University of Washington in 1926 with a degree of bachelor of science in electrical engineering. He also did graduate work in the field of hydroelectric power and transmission. In 1928, he began his employment with the Department of Lighting of the City of Seattle. He actively promoted the raising of the Skagit Project transmission voltage from the existing 165 kv to 230 kv and made the economic analysis on which the decision to go to the higher voltage was based. He had charge of the location, design, and construction of the first 230 kv transmission line in the Northwest, a line 121.8 miles long from the Skagit project to Seattle. In 1948, Mr. Strandberg was appointed project engineer in charge of transmission engineering. The scope of this assignment included the location, design and construction of the second 230 kv transmission line. He also had charge of the design and construction of three 230 kv substations, a major component of the City of Seattle's 230 kv transmission system. In 1952, Mr. Strandberg was appointed supervising senior engineer; in 1953, chief electrical engineer; and in 1955, chief engineer. In this last position, he has administrative direction of engineering, including hydroelectric projects contemplated and under construction. In his 27 years with Seattle City Light, the system load has grown from 100 mw to 650 mw. Mr. Strandberg has been responsible for and has made substantial contributions to the engineering and construction of plants to meet this load growth. He is the author of several technical papers and articles, the most recent being, "30-Years Experience with Wood-Pole Transmission Line Construction," CP, AIEE Summer and Pacific General Meeting, Los Angeles, Calif., June 1953. Mr. Strandberg has served on the AIEE Transformers Committee (1953–56).

Finley Womack Tatum (AM '42, M '45), professor and chairman, Department of Electrical Engineering, Southern Methodist University (SMU), Dallas, Tex., has been transferred to the grade of Fellow in the AIEE "...for his contributions in the field of engineering education." Mr. Tatum was born in Kent, Tex., on July 9, 1914. He attended Columbia University where he received his bachelor of science degree in electrical engineering in 1935, and his master's degree in 1946. From 1935 to 1947, he was employed by the American District Telegraph Company, New York, N. Y., and in 1947, he began his association with the department of electrical engineering of SMU. He was appointed assistant professor in 1947, associate professor in 1948, professor in 1950, and chairman in 1951. His duties include the organization and teaching of junior and senior level courses in a-c circuits, networks, measurement, and control; and graduate level courses in operational calculus, servomechanisms, switching circuits, and digital computers. He also supervises the undergraduate and graduate electrical engineering department. From 1952 to 1954, he was on leave from SMU, serving as a member of the technical staff, Bell Telephone Laboratories, New York, N. Y. In this capacity, he taught in the company's communication development training program and engaged in exploratory development of electronic systems of the digital control type. In 1953, he assisted with the organization and running of a short course in the design of digital control circuits, given by the Laboratories to a group of electrical engineering professors. Mr. Tatum serves on the graduate council at SMU and was primarily responsible for the establishment and operation of the Engineering Graduate Division at SMU. He is a member of the Institute of Radio Engineers (IRE), and the author of a paper, "Design of Logic Circuits for Digital Control Systems," presented at the IRE Southwestern Conference and Electronics Show, February 1955, Dallas, Tex. Mr. Tatum is a member of Sigma Tau and Eta Kappa Nu. He has served on the following AIEE committees: Student Branches (1949–55, chairman 1951–53); Professional Division Advisory (1951–52); Joint Subcommittee of IRE Education Committee and AIEE Committee on Student Branches (1951–54); Feedback Control Systems (1953–56); Communication Switching Systems (1954–56).

Joseph Densmore Wood (AM '19, M '27), engineer-in-charge, High Voltage Development, I-T-E Circuit Breaker Company, Philadelphia, Pa., has been transferred to the grade of Fellow in the AIEE "...for contributions to the development and application of switchgear and its components." Mr. Wood was born in Wichita, Kan., November 30, 1894. He received

two bachelor of science degrees, the first in 1915 from Guilford College, N. C., and the second in 1916 from Haverford College, Pa. He also received his master's degree from Haverford in 1917. After a period of teaching mathematics and physics at Wilmington College, Ohio, he joined Westinghouse Electric Corporation, East Pittsburgh, Pa. In his capacity as a design engineer, he worked with circuit breakers, switches, and fuses. Following this, he spent seven years concentrating on oil circuit breaker design, two with General Electric Company, Schenectady, N. Y., and five with the Condit Electric and Manufacturing Company, Boston, Mass. More than 50 patents have been granted to Mr. Wood, nearly half of which were for work in this early period. In 1928, he joined the Roller-Smith Company, Bethlehem, Pa., as chief engineer, becoming president in 1940. During this period, he originated the design of oil circuit breakers up to 15 kv and 250 mva, and the design of metal-clad switchgear for use with these circuit breakers. From 1943 to the present, he has been with the I-T-E Circuit Breaker Company as engineer-in-charge, high voltage department. Mr. Wood has served on the following AIEE committees, Protective Devices (1937–45), Switchgear (1947–56, chairman 1954–56), and Power Division (1954–56).

AIEE PERSONALITIES

Dr. Hanna To Be Awarded Lamme Medal for 1955

Clinton Richards Hanna (AM '24, F '44), associate director of research, Westinghouse Corporation, East Pittsburgh, Pa., has been awarded the 1955 AIEE Lamme Medal "... for his fundamental calculations and developments in the field of electrodynamics and particularly for his achievements in the design of generator voltage regulators, automatic rolling mill controls, and tank gun stabilizers." Presentation of the Medal will be made at the AIEE Summer General Meeting, San Francisco, Calif., June 25. Dr. Hanna, was born in Indianapolis, Ind.,

C. R. Hanna

December 17, 1899, and received his bachelor's degree in electrical engineering from Purdue University in 1922. In 1926, Purdue awarded him a professional electrical engineering degree, and in 1945, an honorary doctor of engineering degree. He has spent his entire engineering career with Westinghouse Electric Corporation, first as research engineer, then successively as manager of the Development Division, manager of the electromechanical department and, since 1944, as associate director of research. Dr. Hanna holds more than 100 patents covering his inventions in sound reproduction, sound motion pictures, regulator devices and systems, hydraulic servomechanisms, gyroscopic stabilization, and aircraft automatic pilots. More than a score of scientific papers have been published by him on these and other subjects. During World War II, Dr. Hanna was credited with developing many control and stabilizing devices, including an electrically controlled hydraulic system that stabilized tank gun mounts by gyroscopic means, enabling gunners to score a high percentage of hits. For this work, he was awarded a Presidential Citation in 1942. In 1949, he was awarded the Howard N. Potts Medal by the Franklin Institute. Dr. Hanna is a member of the Institute of Aeronautical Sciences, the Institute of Radio Engineers, Sigma Xi, Tau Beta Pi, Eta Kappa Nu, and he is a Fellow of the Acoustical Society of America. Dr. Hanna has served on the AIEE Basic Sciences Committee (1938–49, 1951–52).

W. E. Gutzwiller (AM '30, M '40) has been appointed manager of the electronics section of Allis-Chalmers Manufacturing Company. He had been engineer in charge of rectifier sales. Mr. Gutzweiler came to Allis-Chalmers in 1931. He is the author of numerous technical papers and holds inventions and patents. He is a member of the Electrochemical Society, the National Electrical Manufacturers Association, and he has served on the following AIEE committees: Chemical, Electrochemical and Electro-Thermal Applications, 1941–56; and Industrial Power Rectifiers, 1947–56.

James Marsden (AM '48), research associate of General Electric's Research Laboratory, has been appointed manager of a new long-range Insulation Materials Study Project in General Electric Company's Chemical Development Department. Dr. Marsden, a native of Sydney Mines, N.S., Canada, received his bachelor of science degree with honors in chemistry from Mount Allison University, Sackville N.B., Canada. He served as full-time instructor in chemistry at his alma mater for one year, then attended McGill University, Montreal, Que., Canada. He earned his doctor of philosphy in chemistry at McGill in 1936. Subsequently, he did postdoctorate research at Cambridge University in England on an 1851 Exhibition Fellowship. He joined General Electric's Research Laboratory as a research associate in 1938. While at the Laboratory, he pioneered in research on silicone rubber and silicone insulating varnishes and tapes. He was a leader in transforming silicone rubber from a laboratory curiosity into a commercially available product, being responsible for development of a large-volume manufacturing process. In 1946, Dr. Marsden became head of the chemistry section in the Laboratory's Atomic Power Division. He was appointed manager of the chemistry and chemical engineering section at Knolls Atomic Power Laboratory (KAPL) in 1951. The following year, he was named manager of operations at KAPL, assuming direction of pilot plants operations, manufacturing facilities, machine shop services, and other activities. He rejoined the Research Laboratory's scientific staff in 1954 to continue work in the field of silicone high polymers, an assignment preceding his present appointment.

L. C. Harriott (AM '42), engineer, has been appointed manager of control systems engineering in General Electric's General Engineering Laboratory. A native of New York, N. Y., Mr. Harriott received a bachelor of electrical engineering degree from New York University in 1941 and a master's degree in electrical engineering from the same university in 1948. He joined General Electric (GE) on the company's test program in June 1941, and six months later was called to military service. He served four years with the U. S. Army Corps of Engineers and was discharged in 1946 with the rank of captain. For two years, he was an instructor in electrical engineering at New York University while studying for his master's degree. In 1948, he returned to GE in the technical education unit, and the following year joined the staff of the company's General Engineering Laboratory. Mr. Harriott is a member of the National Society of Professional Engineers, the New York State Society of Professional Engineers, the American Standards Association, and served on the AIEE Feedback Control Systems Committee, 1952–55.

Milton Leland (AM '54), 13 years with the Burndy Engineering Company, Norwalk, Conn., and former technical service engineer, has been named engineering manager of the Original Equipment Manufacturers and Military Products Division.

R. R. Jenness (AM '44, M '51), associate professor of electrical engineering at the Northwestern Technological Institute (NTI), Evanston, Ill., was elected president of the National Electronics Conference at a recent annual meeting of its board of directors. The National Electronics Conference is a nation-wide forum on electronic developments and their applications. Founded in 1944, its headquarters are in Chicago, Ill. Sponsors of the organization are the AIEE, Northwestern University, Illinois Institute of Technology, University of Illinois, and the Institute of Radio Engineers. Professor Jenness, director of the analogue computer laboratory at NTI, was vice-president of the organization in 1955. He did his undergraduate work at Worcester Polytechnic Institute and holds a master's degree from NTI. He has been on the NTI faculty for 13 years, and is a member of the Institute of Radio Engineers, Instrument Society of America, and the American Society for Engineering Education.

Adolph Lovoff (AM '37, M '44), engineer, Vitro Corporation of America, New York, N. Y., has been appointed general manager of their instrument division. At the Vitro Corporation of America, Mr. Lovoff worked closely with Argonne National Laboratory personnel in evaluation of economic, nuclear, and heat-transfer aspects of boiling water reactors. He holds a bachelor of science degree in electrical engineering from Lawrence Institute of Technology, and a master of science degree from the University of Michigan and from California Institute of Technology. Mr. Lovoff is a member of the American Nuclear Society, American Association for Advancement of Science. Institute of Radio Engineers, Optical Society of America, and Sigma Xi.

H. R. Huntley (AM '23, F '51), head of the transmission section of the American Telephone and Telegraph Company (AT&T), has been named assistant chief engineer of a new engineering division of AT&T. The division will handle radio, customer equipment including special services, and defense activities. Mr. Huntley's telephone career began in 1916, as a transmission and

H. R. Huntley

protection man with the Wisconsin Telephone Company. He left Wisconsin in 1930 to join AT&T in the plant engineering division, handling inductive co-ordination matters with power organizations. In 1942, he moved to the transmission section, first in charge of electrical co-ordination, and then, toll transmission, becoming head of the section in 1951. Mr. Huntley has served on the following AIEE committees: Standards (1947–55); Wire Communications Systems (1950–56, Chairman 1954–56); and Communications Division (1954–56). He is a graduate of the University of Wisconsin, a senior member of the Institute of Radio Engineers, a member of the Montclair Engineering Society, and of Eta Kappa Nu.

H. L. Hazen (AM '26, M '40, F '43) professor of electrical engineering and dean of the graduate school at the Massachusetts Institute of Technology, has been elected trustee of Robert College of Istanbul. He has co-operated in the design and construction of important electrical devices and been associated with Dr. Vannevar Bush in the development of the differential analyzer. Dr. Hazen has contributed notably to the technical literature in electrical engineering especially in the field of instrumental calculation, automatic control devices, and in engineering education. In 1951, he headed the Engineering Education Mission to Japan. During World War II, Dr. Hazen served as Chief of Division Seven of the National Defense Research Committee and was awarded the President's Certificate of Merit for his work in the field of ordnance fire control. Since 1948, he has been a member of the Advisory Council of the Department of Electrical Engineering at Princeton. From 1952 to 1954 he was a member of the Signal Corps Task Force on Scientific Engineering Personnel and has been a member of the U. S. Naval Proving Ground Advisory Council since 1952. Dr. Hazen is a Fellow of the American Academy of Arts and Sciences, and a senior member of the Institute of Radio Engineers. From 1950 to 1954, he was chairman of Region II of the Education Committee of the Engineers Council for Professional Development (ECPD), the working committee which provides ECPD with recommendations based on inspections and appraisals for its officially recognized list of accredited undergraduate engineering curricula in the United States. He was appointed general chairman of the Education Committee and member of the Executive Committee, ECPD, in October 1954, having been a council member since 1952. Dr. Hazen recently spent some time in Turkey where he made a survey of the Robert College Engineering School which awards degrees in civil, mechanical, and electrical engineering. Graduates of the Robert College Engineering School have been responsible for much of the industrialization of the Near and Middle East. Mr. Hazen has served on the following AIEE committees: Basic Sciences (1938–46, 1948–49, Chairman, 1939–41); Technical Program (1939–41); Research (1939–40); Sections (1942–43); Lamme Medal (1945–46, 1948).

J. D. Leitch (AM '38, M '42, F '48), vice-president of the Electric Controller and Manufacturing Company, a division of the Square D Company, has been named vice president, engineering. Dr. Leitch will have his headquarters in the Detroit, Mich., executive offices and co-ordinate engineering activity for Square D plants in nine United States cities and in Toronto, Ont., Canada and Mexico City, C. F., Mexico. He was formerly with the Electric Controller Company, prior to its recent merger into the Square D Company as an operating division. A graduate of the University of Glasgow, Scotland, with a bachelor of science, and the University of Toronto, with a doctorate in physics, Dr. Leitch joined the Electric Controller Company in 1937 in charge of product development. He was named chief engineer in 1943 and vice-president in 1952. Dr. Leitch was earlier associated with the Steel Company of Canada and was a member of the faculty of the University of Toronto. He is a member of the Cleveland Physics Society, and an associate member of the Association of Iron and Steel Engineers. Mr. Leitch has served on the following AIEE committees: Industrial Control (1945–51; Chairman, 1947–49); Industry Division (1947–51, 1953–54); Electronics (1946, 1948–49); Technical Program (1947–51); Standards (1947–49); Award of Institute Prizes (1952–54).

E. E. Charlton (AM '45), nationally known authority on high-voltage and X-ray devices, and consultant on nucleonics and radiation, has retired after more than 35 years on the staff of the General Electric Research Laboratory. Dr. Charlton's career has included 26 years as manager of the Laboratory's X-ray section where he directed the development of a large number of

E. E. Charlton

devices, including the million-volt X-ray unit now extensively used in hospitals for cancer treatment and in industry for the X-raying of metal parts. The 1-million electron-volt (1 Mev) X-ray generator, a source of high-energy electron beams used in studies of food sterilization and electron chemistry, was also developed under his direction. Born in Meriden, Iowa, on September 17, 1890, Dr. Charlton was graduated from Grinnell College, Iowa, in 1913. In 1918 he received his doctorate in chemistry from the University of Illinois. During 1918 and 1919 he served as a lieutenant in the Chemical Warfare Service, as instructor in chemistry at the University of Illinois, and as a staff member of E. I. du Pont de Nemours and Company (Inc.). The following year he joined the staff of the Research Laboratory in Schenectady. Although originally trained as a chemist, his initial investigations of the chemical problems of sodium lamps led him into electronics, where he concentrated most of his later efforts. During his long and distinguished career he worked on a variety of problems concerning vacuum tubes, including the introduction of "getters" (substances which remove traces of gas) and the use of alkali metal vapors. He was in charge of the groups responsible for construction of General Electric's 10 Mev, 50 Mev, and 100 Mev electron accelerators, in addition to the 70 Mev synchrotron. Under his direction, the use of hard glass envelopes for X-ray tubes was introduced and came into general use. Methods of obtaining high-voltage X-rays by means of a multisection tube, as developed by W. D. Coolidge, were applied with Dr. Charlton's help. He became a consultant in the nucleonics and radiation section of the electron physics research department in 1954. In 1954, he was named the Mehl Honor Lecturer for the annual convention of the Society for Nondestructive Testing, Inc. He is a mem-

ber of the American Physical Society and Sigma Xi, and has served on the following AIEE committees: Therapeutics (1946–January '49, Chairman 1947–January '49); Communications and Science Co-ordinating Committee (1947–January '49); Standards (1947–January '49); Technical Program (1947–January '49).

W. M. Dusenberry (AM '45), division manager of Line Material Company, has been appointed sales manager. He assumes his new duties in the company's main office in Milwaukee, Wis. Mr. Dusenberry joined Line Material Company as a field engineer in 1944 and was promoted to division manager in 1948.

B. C. West (AM '39, M '46), past chairman of the Tacoma Sub-Section and apparatus engineer for the Federal Pacific Electric Company at Seattle, Wash., is now stationed at San Francisco as assistant to the western regional manager and is headquartering at the Pacific Switchgear Division of the Federal Pacific Electric Company.

A. J. Sanchir co (AM '50), associate engineer, has been appointed project engineer at the Airborne Computer Laboratories of International Business Machines Corporation's (IBM) newly formed Military Products Division at Vestal, N. Y. Mr. Sanchirico joined IBM as a design engineer in 1951, shortly after receiving his bachelor of science degree in electrical engineering from The City College of New York.

OBITUARIES

Horatio Burt Williams (M '41), Dalton Professor of Physiology, Columbia University, New York, N. Y., died recently. Mr. Williams was born in Utica, N. Y., September 17, 1877. He received his doctor of medicine degree in 1905 and an honorary doctor of science degree in 1925, both from Syracuse University. From 1907 to 1911, as assistant professor of physiology, Cornell Medical School, he did pioneer work with electrocardiographs. In 1911, as associate professor of physiology, Columbia University, he constructed the Einthoven galvanometer and accessories for electrophysiological investigation. During World War I, he served in the U. S. Army as captain of engineers. Following this, he returned to Columbia, engaging in graphic studies of heart sounds in 1920. He was made Dalton Professor and executive officer of the department of physiology, in 1922. In this same year, he became director and technical advisor of the Cambridge Instrument Company, Inc. Mr. Williams was a member of the Council on Physical Therapy of the American Medical Association for many years. He was a member of the American Mathematical Society, the National Society of Professional Engineers, and a charter member of the Society of American Military Engineers. He was a Fellow of the American Physical Society, the Physical Society of London, and the Acoustical Society of America. Mr. Williams served on the AIEE Safety Committee (1943–55).

Harry A. Weitzman (AM '26), manager, rate and economic research department, Rochester Gas and Electric Corporation (RG and E), Rochester, N. Y., died March 22, 1956. Mr. Weitzman was born in Newark, N. J., in 1901, and graduated from the University of Michigan in 1924 with a bachelor of science degree in electrical engineering. He became associated with the George B. Cheney Engineering Company upon graduating, and he joined RG and E in January 1934. Mr. Weitzman had many affiliations in the utility field. He was a member of several committeees in the American Gas Association and Edison Electric Institute. He was also a member of the National and Rochester chapters of the American Marketing Association, the American Management Association, the American Meteorological Society, the Association of Edison Illuminating Companies, Bureau of Municipal Research, the Rochester Chamber of Commerce, and the Rochester Engineering Society. In 1946, Mr. Weitzman served as a consultant in the United States Civilian Production Administration.

MEMBERSHIP

Recommended for Transfer

The Board of Examiners at its meeting of March 15, 1956, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Member

Adams, R. F., assistant professor of electrical engineering, Villanova University, Villanova, Pa.
Amundson, R. H., application engineer, Line Material Co., South Milwaukee, Wis.
Antosy, S. J., field engineer, RCA Service Co., Inc., Camden, N. J.
Barlow, E. P., electro-mechanical staff, The Glenn L. Martin Co., Baltimore, Md.
Bates, J. L., president, Central Power & Light Co., Corpus Christi, Tex.
Bauer, F., section and unit supervisor, Ford Div., Ford Motor Co., Dearborn, Mich.
Bently, D. E., senior engineer, Electronic Products Corp., Santa Barbara, Calif.
Bessom, R. H., engineering and service manager, Westinghouse Electric Corp., Boston, Mass.
Betts, D. C., appcliation engineer, Westinghouse Electric Corp., Seattle, Wash.
Boucher, G. E., manager, Paris Public Utilities, Paris, Ont., Can.
Britton, H. E., product design engineer, General Electric Co., Syracuse, N. Y.
Burritt, A. H., group supervisor, Eastman Kodak Co., Rochester, N. Y.
Carter, H. G., assistant to operating manager, Puget Sound Power & Light Co., Seattle, Wash.
Cary, W. F., electrical design engineer, Refinery Engineering Co., Tulsa, Okla.
Casasza, J. A., engineer, Public Service Electric & Gas Co., Newark, N. J.
Cohen, J., electrical engineer, Bell Aircraft Corp., Buffalo, N. Y.
Creed, F. C., associate research officer, National Research Council of Canada, Ottawa, Ont., Can.
Creitz, W. M., system distribution engineer, Metropolitan Edison Co., Reading, Pa.
Duncan, A. M., electrical engineer, USAF, Pepperrell AFB, Newfoundland, St. Johns, Can.
Ehrlinger, R. J., research assistant, The Johns Hopkins University, Baltimore, Md.
Eichenberg, C. L., engineer, Bethlehem Steel Co., Bethlehem, Pa.
Ferguson, W. B., consulting electrical engineer, 513 The Arcade, Cleveland, Ohio.
Flower, R. L., development engineer, General Electric Co., Schenectady, N. Y.
Foltz, H. M., Jr., application engineer, Lowry Electric Co., Inc., Williamsport, Pa.
Gilroy, E. W., department representative, The Glenn L. Martin Co., Baltimore, Md.
Gomersall, J. R., director of research, Toastmaster Div., McGraw Electric Co., Elgin, Ill.
Guinn, J. R., Jr., assistant professor, Texas College of Arts & Industries, Kingsville, Tex.
Harris, C. E., supervisor of relays, Duke Power Co., Charlotte, N. C.
Hawkins, E. S., assistant engineer, Baltimore Gas & Electric Co., Baltimore, Md.
Jones, L. R., chief commercial engineer, Dictaphone Corp., Bridgeport, Conn.
Kaltenberger, L. H., technical adviser, The Chemical Process Co., Breckenridge, Tex.
Kazarian, R., assistant engineering manager, Tocco Div., Ohio Crankshaft Co., Cleveland, Ohio.
Keith, R. H., apparatus engineer, Line Material Co., East Stroudsburg, Pa.
Kremser, A. W., district manager, Allis-Chalmers Mfg. Co., Davenport, Ia.
Lipinski, M. G., assistant electrical engineer, J. G. White Engineering Corp., New York, N. Y.
Logue, R. H., substation design engineer, Philadelphia Electric Co., Philadelphia, Pa.
Malone, J. J., building engineer, Northwestern Bell Telephone Co., Fargo, N. D.
Mattern, R. M., supervising radio engineer, The Ohio Bell Telephone Co., Cleveland, Ohio.
Miller, J. R., principal engineer, Kansas City Power & Light Co., Kansas City, Mo.
Ossman, W. R., engineer, Cleveland Electric Illuminating Co., Cleveland, Ohio.
Owen, W. E., associate professor of electrical engineering, Louisiana State University, Baton Rouge, La.
Park, L. G., district office manager, Allis-Chalmers Mfg. Co., Shreveport, La.
Patel, B. P., senior executive engineer, Bombay State Electricity Board, Bombay, India.
Peterson, R. E., eastern division manager, Line Material Co., East Stroudsburg, Pa.
Rodriguez, B. S., electrical engineer, Gilbert Associates, Inc., Reading, Pa.
Sams, W. T., vice president, Southern Electric Co., Inc. Jacksonville, Fla.
Schmidt, A. D., assistant engineer, Baltimore Gas & Electric Co., Baltimore, Md.
Smith, D. D., partner, Roushey & Smith, Brooks Bldg., Wilkes-Barre, Pa.
Stanford, J. H., Jr., senior instrumentation engineer Glenn L. Martin Co., Baltimore, Md.
Thornton, C. R., district manager, Canadian Line Materials, Ltd., Ottawa, Ont., Can.
Torbit, J. G., manager, engineering switchgear assemblies, General Electric Co., Philadelphia, Pa.
Trebby, F. J., electronic research engineer, Kaiser Aluminum & Chemical Corp., Spokane, Wash.
Wade, S. R., chief electrical engineer, Hayes, Seay, Mattern & Mattern, Roanoke, Va.
Wilhite, J. G., Jr., electrical engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.
Wynkoop, W., assistant general foreman, Bethlehem Steel Co., Bethlehem, Pa.
Ylarraz, J. N., electrical engineer, Pacific Gas & Electric Co., San Francisco, Calif.
Yocom, H. E., Jr., engineer, Gilbert Associates, Inc., Reading, Pa.

57 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership in the grade of Member, have been received from the following candidates, and any member objecting to election should so notify the Secretary before May 25, 1956, or June 25, 1956, if the applicant resides outside of the United States, Canada or Mexico.

To Grade of Member

Allen, R. C., General Electric Co., West Lynn, Mass.
Arnott, W., Jr., Burndy Engineering Co., Norwalk, Conn.
Azua, R. V., General Electric, S.A. de C.V., Mexico, D.F., Mexico
Becker, K. E., Hevi Duty Electric Co., Milwaukee, Wis.
Bonney, A. G., The Louis Allis Co., Milwaukee, Wis.
Busignies, H. G., Federal Telecommunication Laboratories, Nutley, N. J.
Cortes, M. T., Dept. of Labor, Div. of Industrial Safety, Quiapo, Manila, P.I.
DeLutis, T., National Electric Products Corp., Ambridge, Pa.
Dodd, F. J., General Electric Co., Rome, Georgia.
Ekefalk, S. H., Swedish State Power Board, Stockholm, Sweden.
Ferguson, A. W., Boston Edison Co., Boston, Mass.
Fuston, R. E., Kelsey-Hayes Wheel Co., McKeesport, Pa.
Giles, R. B., Consulting Engineer, London, England.
Herr, C. C., Western Electric Co., Chicago, Ill.
Hirsch, C. J., Hazeltine Corp., Little Neck, N. Y.
Horner, A. R., Public Service Elec. & Gas Co., New Brunswick, N. J.
Hubbard, W. L., W. S. Gordon, Consulting Engineer, Tacoma, Washington.
Jancke, G., Swedish State Power Board, Stockholm, Sweden.
Levi, F., Rola Co. (Australia) Pty. Ltd., Victoria, Australia
Lovely, W. S., Merz & McLellan, Milburn, Esher, Surrey, England.
Newton, R. Y., General Electric Co., Schenectady, N. Y.
Rao, C. V., India Government Mint, Calcutta, India.
Rich, E., British Insulated Callender's Construction Co., Ltd., Vancouver, B.C., Canada.
Saxenmeyer, G. J., I.B.M., Endicott, N. Y.
Smith, C. E. (re-election), Smith & Silverman, New York, N. Y.
Steere, R. M., Louisiana Polytechnic Institute, Ruston, La.
Yadoff, O., Applied Physics Research Foundation, Inc., Palo Alto, Calif.

27 to grade of Member

IN EDUCATIONAL CIRCLES

ACTIVITIES AND INTERESTS

AIEE Is a Postgraduate School

L. F. HICKERNELL

FELLOW AIEE

HAVING ENJOYED what amounts to a second career in the American Institute of Electrical Engineers, I want to recommend, unqualifiedly, to all students of electrical engineering and young graduates in that field, membership in the Institute and participation in its activities. Professionally, technically, and socially, you will find the AIEE stimulating and broadening.

AIEE is essentially a lifetime postgraduate school; however, no graduate school in the world offers so much education for so little "tuition" (dues). Because this statement may sound dogmatic or exaggerated, I shall attempt to support the thesis by some detailed explanation of the activities of the Institute.

Within the Student Branch, classroom work is supplemented by projects planned by the students themselves. Officers are elected to perform administrative duties. Meetings are planned, speakers obtained, and technical papers written and discussed. Here you can enjoy being part of a professional unit for the first time.

Upon "graduation" from your Student Branch at school, as a graduate electrical engineer you automatically become a member of the nearest local geographical Section. At Section meetings, you not only have the privilege of furthering your technical education by hearing speakers who are specialists on various subjects, but also the opportunity to discuss your current problems with others in the profession.

In addition to the regular Section Meetings, many of the larger Sections conduct round-table discussions and educational courses, including refresher courses for examinations leading to State registration as a Professional Engineer.

As you show progress in your work and demonstrate an aptitude for assimilating more advanced information, you are likely to be authorized by your employer to attend District and General Meetings.

In addition to technical advancement, important to you as a young graduate engineer, you will find that opportunities for professional and personal friendships also develop in the committee work of the Section, as they do later, in the District and General Committees. AIEE brings together electrical engineers from all parts of North America and the world, and from all of the many different industries and specialties in which electrical engineers work. Many of us find that our oldest, best, and professionally most stimulating friendships have developed through AIEE quite as much as through intimate business associations. In fact, were it not for AIEE, "radio men," "power men," "telephone men," "research men," "manufacturing men," and "professors," even though all are electrical engineers, would rarely get together.

Upon attaining proficiency in your specialty or field, or having given indication of your capacity to do so, you may be appointed to a Technical Committee. Here you have an exceptional opportunity to learn of the latest developments and to exchange ideas with outstanding leaders in the profession.

It is an interesting experience to sit with a group of fellow engineers and discuss a problem, technical or administrative. Within the group will be men of varied backgrounds and affiliations. Their approach to the problem at hand is likely to vary. You submit your own ideas, the others present theirs, then comes the need to sift, to compare, to sort suggestions, and to arrive at a conclusion. This type of meeting develops your judgment and your ability to listen and to compromise, attributes which carry over into your daily associations.

In addition to its monthly periodical *Electrical Engineering*, which contains articles of professional, technical, and general interest, the Institute publishes some 400 technical papers in 3 categories in its bimonthly periodicals, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*. Annually, these are bound into volumes known as "Transactions" which have been published since the Institute was organized in 1884. It may be of interest to point out that the first paper in Volume 1 was on the "Edison Effect." Entitled, "Notes on Phenomena in Incandescent Lamps," by Prof. E. J. Houston, it discusses the basic principle of the modern electron tube.

Unfortunately, space does not permit covering all of the Institute's activities. However, the foregoing should demonstrate that "AIEE is a postgraduate school" in that it has the most essential elements:

CLASSROOMS—Section, District, and General Meetings.

SEMINARS—round-table discussions, Technical Conferences, Technical Committee Meetings.

FACULTY—speakers and authors of papers.

TEXTBOOKS—*Electrical Engineering* (monthly); "Transactions" (annual) consisting of I. *Communication and Electronics* (bimonthly), II. *Applications and Industry* (bimonthly), and III. *Power Apparatus and Systems* (bimonthly); Special Publications (symposia), and Standards.

SOCIAL ACTIVITIES—Section and Meeting Committees, General Committees.

All that remain are Honors. The Institute has these, too:

DIPLOMAS—Grades of Membership: Associate Member, Member, Fellow, and Honorary Member.

AWARDS—AIEE: Edison Medal and Lamme Medal; Joint Societies: Hoover Medal, John Fritz Medal, Sperry Medal, Marston Medal, Washington Award, and Alfred Noble Award.

FELLOWSHIP—Charles LeGeyt Fortescue.

PRIZE PAPERS—Institute: Division (5), Non-Division, and Student; District: any class, Undergraduate; Section (2); and Branch.

Officers and Chairmen of the Institute are eager to find new workers, realizing that the vitality and future of the organization depend upon obtaining and developing young talent. Yet frequently the question is asked: "How can I, as a young graduate, get started in AIEE activity?" Of many avenues, probably two are the simplest and most direct: at the conclusion of a meeting, introduce yourself to the Section Chairman and tell him you are available for a committee assignment (it is best to confirm this in writing, the Chairman may forget it by the time he reaches his office); if one of the members of your organization is a Past or Present Section Officer or a Committee Chairman, advise him of your willingness to take part, and ask his advice about whom you should contact within the Section organization.

Your role as AIEE member may, of course, be a passive one. If you elect not to engage in committee work, your membership still will serve you well in keeping you abreast of developments in the entire range of electrical engineering subjects. You will find that one of the 43 national Technical Committees acts as a clearing house for information on, and contributes to the advancement and his-

L. F. Hickernell is chief engineer, Anaconda Wire and Cable Company, New York, N. Y., and an AIEE Director.

torical record of, subjects within your field of specialization.

If, however, you choose to take part in the affairs of the Institute, many fine opportunities await you. Your matriculation at AIEE, a lifetime Postgraduate School, will be invaluable in advancing your career as an electrical engineer.

Professional Record

EDITOR'S NOTE: Mr. Hickernell became a Student Member in 1920, while enrolled at MIT. He was advanced to the grade of Fellow in 1934, at the age of 34, one of the youngest ever to attain this highest grade below that of Honorary Member. He was elected a Director on January 1, 1953. That he writes from first-hand experience is evident from his Institute record, which follows.

Membership: Student, 1920; Associate Member, 1925; Member, 1927; Fellow, 1934.

Detroit–Ann Arbor Section: Meetings and Papers Committee (1926–31), Chairman (1926–27), Vice-Chairman (1927–28), Secretary-Treasurer (1928–29), Chairman (1929–30); Executive Committee (1926–31), Chairman (1929–30); 1927 Summer Convention Committee (1926–27).

Great Lakes District No. 5: Executive Committee (1928–30).

Technical Committees: Electrical Machinery Committee (1929–33), Chairman, Annual Report Subcommittee (1930–31); Protective Devices Committee (1929–32), Vice-Chairman (1930–32), Chairman of Oil Circuit Breaker, Switches and Fuses Subcommittee (1930–32); Power Transmission and Distribution Committee (1930–42, 46–47); Insulated Conductor Committee (1947–56), Chairman (1947–49).

General Committees: Publication Committee (1934–35, 51–54); Board of Examiners (1941–56), Vice-Chairman (1953–55); Standards Committee (1947–49); Technical Program Committee (1947–50); Power Division Committee (1947–49), Chairman (1949–51), Member-at-Large (1951–53); Award of Institute Prizes Committee (1949–50); Technical Advisory Committee (1950–51), Chairman (1951–52); Technical Operations Committee (1952–56), Chairman (1952–54), Member-at-Large (1954–56); Public Relations Committee (1952–54); Edison Medal Committee (1954–56).

Board of Directors: Director (elected January 1, 1953, to fulfill unexpired term of W. J. Barrett), Director (1953–57); Planning and Co-ordination Committee (1949–56), Chairman (1954–56); Executive Committee (1954–56).

AIEE Representative: Engineers Joint Council, alternate (1953–55), member (1956); World Power Conference, U. S. National Committee, alternate (1954–56).

RPI Reports Results of Educational Experiment

An educational experiment at Rensselaer Polytechnic Institute (RPI) has indicated that colleges of science and engineering could successfully advance some students to graduate studies without benefit of the senior year.

This finding, regarded as highly important in light of the urgent need for scientists and engineers, particularly for those with advanced degrees, was the result of a six-week experimental program conducted at the Institute last summer. This was disclosed in a report published by Dr. A. A. Burr, professor and head of the department of metallurgical engineering, RPI.

Ten students, who had just completed their junior year and who had been carefully screened for promise of brilliant achievement, were selected from 10 colleges and universities to participate in the experiment. Their previous experience had been in the field of physics, chemistry, and metallurgical engineering.

In the six weeks at RPI they were in the hands of top professors and co-operating scientists from the research laboratories of the General Electric Company.

Dr. Burr reports that they were required to reach a level normally considered only within the capabilities of graduate students.

Those who administered the experiment felt that approximately half of the group could easily undertake studies toward advanced degrees without further undergraduate training, and that the performance of all but one would have merited six credit hours of graduate work. It is believed that the experiment clearly indicates that serious consideration should be given in the future to the possibility of segregating the topmost students in science and engineering in order that they may take advantage of their exceptional talent to become productive sooner as well as to be stimulated to higher levels of activity.

Dr. Burr also stated that probably 5 to 10 per cent of the engineering juniors in the United States would be able to absorb graduate work successfully without senior-year training, if given the opportunity.

The effect of the summer experiment on the students themselves was described by one of the group who stated that the effect was well reflected in the facts that 9 of the 10 who participated will work for an advanced degree and that during the entire six weeks no one was absent from any class. The students felt that contact with such a select group of instructors was as much a part of their education as learning the material that was presented.

The two courses given dealt with the chemistry and physics of metals, extremely important fields in relation to new severity of requirements demanded of metals in their uses, for example, in atomic energy develop-

State College of Washington Membership Challenge

Courtesy State College of Washington

RECENT APPLICATIONS will result in 100 per cent of the junior class of the department of electrical engineering, State College of Washington, Pullman, Wash., having national membership in the AIEE or the Institute of Radio Engineers (IRE). The senior class has previously attained this goal. It is believed that the AIEE-IRE Joint Student Branch at this college is the only student branch to claim a true 200 per cent Club, 100 per cent of the seniors and 100 per cent of the juniors. In addition, there are a sufficient number of sophomores who are national members to boost the membership to 280 per cent. Because of these facts, State College of Washington offers a challenge to other colleges in the United States to top this goal.

ments, in jet engines, and in guided missiles.

In general, classes were held Monday through Friday. Seventy-two lecture hours were presented in morning sessions and 20 hours of seminar in two-hour periods were presented afternoons. Afternoons not occupied by seminar were devoted to library and study periods. The amount of student instructor contact in the six weeks was equivalent to what would normally be experienced in a regular semester for six credit hours.

In the six weeks the students were in contact with 26 different lecturers, all active research workers and all authors of scientific literature. All, except two, held doctorates.

The students had a section of a Rensselaer dormitory practically to themselves and, thus, were easily able to gather for discussion, bull sessions, and recreation. An evening dinner and an outdoor picnic with their faculty quickly "broke the ice" between the two groups.

The students who participated in the experiment came from RPI, Siena College, DePaul University, University of Cincinnati, Oberlin College, Michigan State, Boston College, DePauw University, Illinois Institute of Technology, and Montana School of Mines.

Dr. Burr said plans are under way to repeat the experiment next summer. Each participant will be given a full-tuition scholarship, and travel and living expenses as well. He said he would welcome inquiries from college juniors who feel qualified.

AIEE Student Branch Formed at San Francisco Section

A new student branch of the San Francisco Section of AIEE has been formed at the U. S. Naval Postgraduate School, Monterey, Calif. This raises the number of student branches in the Section to five. During ceremonies attending the formation of the branch, Bradley Cozzens, Eighth Region vice-president, presented a student branch charter to Lt. W. L. Harris, USN, branch chairman. Representing the Section at the ceremony were W. G. Collins, vice-chairman; C. F. Dalziel, secretary-treasurer; and W. A. Howe, ex-officio.

Speakers for the occasion included the section representatives, and Capt. C. T. Singleton, USN, director of the engineering school, Prof. C. V. O. Terwilliger, chairman of the school's electrical engineering department, and Lt. W. L. Harris.

The following branch officers were elected for the remainder of the academic year: Lt. W. L. Harris, chairman; Lt. C. A. K. McDonald, USN, vice-chairman; Lt. W. C. Klemm, USN, secretary; Lt. L. A. Marckensano, USN, treasurer; and Associate Prof. C. B. Oler, counselor. The newly formed student branch plans to hold regular and frequent technical meetings, in conjunction with weekly electrical engineering seminars held at the school. Outside speakers already have been scheduled for these meetings; through the students relations committee of the San Francisco Section.

Program for Gifted Students To Begin at UW

A long-range research program designed to discover, at an early stage, high school students of superior ability is being launched this year by the engineering experiment station of the University of Wisconsin (UW) College of Engineering.

In announcing the project, K. F. Wendt, dean of the college, who is also director of the experiment station, emphasized the fact that the program is long range in scope. Its ultimate success depends on co-operation between the University as a whole and the high schools, together with financial support from the state, from industry, and from foundations.

Dean Wendt said that the program is designed not only to discover high school students of superior ability for engineering and science careers, but also to find young students of superior ability for the liberal arts and all professions.

Immediate objectives of the UW's new search for Wisconsin's gifted students are to: develop methods and procedures for finding superior secondary school students in first year high school with potential ability to become engineers or scientists; guide and encourage the academic development of all students identified as superior or gifted in order that they can achieve the maximum in a course of study which will give them entrance to any undergraduate college or to any college of a university; and assist identified superior or gifted students with counsel and financial aid, if needed, until they complete a degree in the college of their choice. Methods now being surveyed in the preliminary phases of the project include programs to: evaluate the quality of training of the students entering in the College of Engineering; establish methods and procedures to find, encourage, and guide superior students from their first year in high school to the college best suited to their needs; develop a plan whereby the identified superior students who need financial aid may be assured college training; and share the methods and results of the research with all other University disciplines.

Dean Wendt explained that the program must have as its initial period at least five years. It requires that length of time for the students who enter high school to graduate as identified students and to matriculate in college. According to plans now under way, a selected group of superior high school students will have been organized for study by next June.

Dr. C. M. Brown has been added to the staff of the UW Engineering Experiment Station to organize and direct the program.

Official Photograph, U. S. Navy

OFFICIAL REPRESENTATIVES of the San Francisco Section and speakers who attended the formation of a new student branch at the U. S. Naval Postgraduate School, Monterey, Calif., included (*left to right*) Captain C. T. Singleton, Jr. USN; W. G. Collins, section vice-chairman; Bradley Cozzens, Eighth Region vice-president; W. A. Howe, section ex-officio member; Lt. W. L. Harris, USN, student branch chairman; C. F. Dalziel, section secretary-treasurer; and C. V. O. Terwilliger.

Engineering Center Proposed at Colorado A & M

One of the first groups of buildings to be constructed by Colorado Agricultural and Mechanical College under its new program authorized at the last session of the Legislature will be for the School of Engineering.

The new Center, which as yet has no official name, will consist of three three-story structures connected by an arcade along the south side. In addition, there will be a fourth and similar building in the assembly devoted to work in Physics; and a separate lecture hall with a capacity of 300. Future expansion will be provided for by a fifth similar building in line with the other four, and a similar large lecture hall adjacent to the first one, when the need arises.

All present buildings in which the School of Engineering teaching facilities are housed will be abandoned to other departments for classroom use. All engineering departments will move into the new Center. Each wing will have laboratories of one department on its first floor, but otherwise there will be no departmental significance to a particular wing. All offices, classrooms, drafting rooms,

and other facilities will be used jointly and be spread throughout the three Engineering wings. The School will become a real, integrated unit instead of several widely separated departments as exist now. The present well-known Hydraulics Laboratory will remain at the west end, and be a part of the proposed new assembly of buildings.

Construction of this new Center is expected to start next Spring, and the few facilities should be ready by Fall 1957. By the following year all indications point to an Engineering enrollment of 800 students.

In addition to the buildings, it is anticipated that considerable improvement will be made in laboratory equipment in all departments to bring the offerings up to date and consistent with current trends in Engineering education.

University of Cincinnati Looks into the Future of America

The University of Cincinnati marked the 50th Anniversary of the founding of cooperative education at the school during a seven-day celebration, April 19–25. The theme, "Education and Industry at Work for Progress," emphasized the contributions of co-operative education to the growth of America. Exhibits from more than 70 large corporations arranged in a "Panorama of Industrial and Scientific Progress," dramatized technological advances in the past 50 years. In conjunction with the "Panorama," which was sponsored by C. R. Osborn, the National Association of Manufacturers presented a traveling exposition entitled "Americade." This dramatic and graphic projection of the United States into 1975 began a five-year tour of the nation recently.

The exhibit is not considered to be an industrial show, inasmuch as it neither exhibits nor promotes any products. Its purpose is to translate blueprints, charts, and other predictions of the great promise of the future into a vibrant, dramatic story. Through spectacular animated displays and the employment of unique lighting and sound effects, the Americade gives broad visual scope to the nation's potential for the attainment of greater heights of prosperity in the next 19 years.

It was explained that many of the Americade exhibits were designed for audience participation. Visitors are able to see themselves on television through a closed circuit system, and also have an opportunity to work the controls of a popular simulated space ship.

A "Growth Exhibit" permits viewers to actually watch America grow. Attuned to the birth rate (a baby is born every 8 seconds), an automatic counting device geared to the U. S. Census Bureau counter in Washington, subtracts deaths and emigrants; adds immigrants to the births, and posts the exact population of the nation at the moment it is being viewed.

Divided into two interrelated sections, first, the series of exhibits portray improvements and expansions anticipated in the areas of job opportunities, homes, food, clothing, religion, education, health, energy, transportation, and communications. The second section demonstrates through objective treatment how the preservation and strengthening of the driving forces of free competitive enterprise, research and invention, productivity, profits and competition, are essential to full realization of the nation's potential.

Leading industrialists from across the nation assembled at the University to participate in the over-all University program.

H. W. Prentis, chairman of the board of Armstrong Cork Company, headed a panel of industrialists and scientists who discussed "America's Progress, 1906–1956."

The Herman Schneider Memorial Quadrangle at the University was dedicated in honor of the originator of the co-operative system of technological education.

S. C. Allyn, president of National Cash Register Company, sponsored a part of the program involving distinguished national figures in the field of science, management, and design, reviewing projections of the next 50 years calling for closer integration of business and education to meet new challenges.

C. R. Hook, chairman of the board of Armco Steel Corporation, guided as much of the program as pertained to the preparation of the future managers, engineers, and designers of the United States.

Switching Circuits Program Offered at MIT Summer Session

A two-week special summer program in "Switching Circuits" will be given at the Massachusetts Institute of Technology (MIT) June 18–29 during the 1956 Summer Session.

Prof. E. H. Huntress, director of the MIT summer session, stated that it is designed for engineers and research workers who are concerned with the development of automatic equipment using switching devices and systems and for teachers who plan to offer courses in switching.

The program will be presented by Dr. S. H. Caldwell, professor of electrical engineering and Dr. D. A. Huffman, assistant professor of electrical engineering, both members of the MIT faculty.

It was pointed out that electronic digital computers, information-processing machines, and a variety of automatic control devices and systems are rapidly being accepted as essential equipment in many areas of commerce and industry. Although they differ in form and function, all of these devices are based on the use of switching circuits.

During the program, emphasis will be placed on developing an understanding of basic principles and concepts in switching and logical design rather than on specific applications.

Lecture topics will include switching algebra, graphical and numerical aids to network simplification, multiple-output networks, sequential circuit synthesis, and memory requirements in synchronous and asynchronous systems.

The mathematical aspects of switching circuits will be developed during the program, and no previous experience with them is required.

Registrants for this special summer program in switching circuits may reserve rooms in MIT's dormitories during the program. All MIT recreational facilities including the swimming pool and the popular sailing pavilion on the Charles River Basin are available for use by the visitors.

Full details and application blanks may be obtained from the Summer Session Office, Room 7-103, Massachusetts Institute of Technology, Cambridge 39, Mass.

Graduate Fellowships Established for RCA Employees

The Radio Corporation of America (RCA) has established 10 graduate fellowships for employees in honor of Brigadier General David Sarnoff, chairman of the board of RCA.

Dr. C. B. Jolliffe, chairman of the RCA Education Committee, said that each fellowship is valued at approximately $3,500, and includes a grant to the fellow, tuition fees, and an unrestricted gift to the college or university selected. The awards will be made in the fields of science, business administration, and dramatic arts.

Recipients of the David Sarnoff Fellowships will be chosen from the various RCA divisions and subsidiaries. Guided by executives of their divisions, employees will choose an appropriate graduate school, and will be given a leave of absence for the duration of the fellowship.

Besides the David Sarnoff Fellowships, RCA is awarding 10 college and university graduate fellowships in the fields of science, physics, electrical engineering, and dramatic arts, including RCA's first fellowship in medical electronics, which has been established at Johns Hopkins University, Baltimore, Md., with a grant of $3,500 to be made in the Fall of 1956.

Nine other RCA graduate fellowships will be awarded to students at the following universities: California Institute of Technology, science; Carnegie Institute of Technology, dramatic arts; Columbia University, physics; Cornell University, engineering physics; University of Illinois, electrical engineering; New York University, electrical engineering; Princeton University, electrical engineering; Rutgers University, physics; Yale University, dramatic arts.

Centennial Program at University of Missouri

The College of Engineering of the University of Missouri, Columbia, Mo., is celebrating the 100th year since the first degrees in engineering were granted by this, the oldest state university west of the Mississippi River.

In connection with the Centennial Program, five engineers who have achieved national and international prominence in their particular fields were presented with Missouri Honor Awards for Distinguished Service in Engineering.

The Honor Award recipients, Dr. J. B. Davidson, W. G. Purdy, L. H. Winkler, G. A. Delaney, and Procter Thomson, received the symbolic bronze medals and copies of their citations from Dean H. O. Croft of the College of Engineering, in ceremonies in Jesse Auditorium which also included presentation of scholarship awards to outstanding students in engineering.

OF CURRENT INTEREST

WATCHING PLANE approaching on one of three monitors in tower control center are Comdr. Robert Corlett, operations officer (left) and Comdr. W. M. Heaman, public works officer; looking on is R. T. Silberman, vice-president, Kay Lab.

Official photograph, U. S. Navy

Closed Circuit Television Used at NAS, Alameda for Runway 25R Extension

A UNIQUE closed circuit television system specifically designed for the purpose of extending the field of vision of an airport control tower operator has been developed by Kay Lab, San Diego, Calif. The need for this system has made itself apparent all over the country because with larger, faster propelled, and jet aircraft, longer runways are a necessity.

Closed Circuit System

The installation at the Naval Air Station (NAS), Alameda, Calif., is the first of its kind. The system probably is one of the most elaborate closed circuit systems in the country, representing remote control facilities over an unusually extensive area.

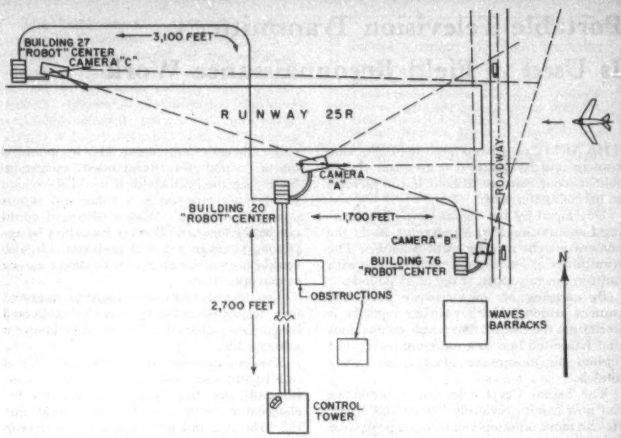
The extension of Runway 25R at NAS, Alameda had sections of the runway out of the line-of-sight of the tower. A road crossing the line of air traffic at the end of the runway brought vehicular and air traffic in dangerously close proximity making it obvious that better surveillance of the runway as well as control of vehicular traffic was necessary. Although traffic lights operable from the control tower were installed, the poor visibility made fool-proof control difficult, if not impossible. The cost of raising or moving the control tower was estimated at one-half million dollars. The cost of the television system was less than $50,000.

Remote Controlled Cameras

To cover the approach of aircraft to the runway adequately, as well as the taxi path after landing and the vehicular traffic along the road, three television cameras were installed. All three cameras are capable of being remote controlled to follow aircraft in flight or on the ground as well as vehicles on the road. Pictures from the three cameras are relayed by coaxial cable to three monitors located at the tower center. As can be seen in the line drawing, camera *A* located at Building 20 looks east covering the first 1,500 feet of runway. This camera is mounted on top of a hanger 43 feet above the runway, and may be panned along the runway east or west. Camera *B* located at Building 76 is south of the end of the runway and looks north along the road. This camera is located 37 feet above the level of the runway and may be panned to the west to follow aircraft over the end of the runway if desired. Camera *C* located at Building 27 normally looks east along 3,000 feet of runway. It can be panned to a limited degree along the runway. This camera is 23 feet above the surface of the runway. Cabling from Camera *B* at Building 76 is brought 1,700 feet under-

ground to Camera *A* control center at Building 20. Cabling from Camera *C* at Building 27 is brought 3,100 feet to Camera *A* control center at Building 20. At Building 20, the video signals from Cameras *B* and *C* are passed through compensated video line amplifiers for a gain of 10 db before being passed on to the control tower some 2,700 feet distant.

All cameras are seated in a thermostatically controlled weatherproof housing containing 300 watt heaters and a forced air ventilating system enabling true all-weather operation. The housing is equipped with windshield wipers for wet weather and a K2 filter which can be lowered in place in front of the camera lens under haze conditions. The camera is equipped with a three lens turret system which permits the operator to select any one of three lenses at will and to focus the camera for that lens. The lenses chosen were 1/2-inch f/1.5 with a horizontal angle of 41.6 degrees, 2-inch f/1.5 at 10.9 degrees, and 6-inch f/2.8 at 3.6 degrees. These lenses allow a much wider variation in field of view at higher lens speeds than could be achieved with conventional zoom or telephoto lenses. Inasmuch as it was desired to operate the system under predawn and dusk lighting conditions, the extra expense of the more efficient optical system was considered well worth the extra cost.



Courtesy U. S. Navy

GENERAL OPERATING PLAN of the closed circuit television system, installed when extension of Runway 25R at NAS Alameda was completed, which thus eliminated the necessity for possible extensive expensive rebuilding of the Control Tower.

Automatic Irises

To take care of changes in light level, an automatic iris was included in the system behind the lens. By means of a servo-mechanism operated by a rectified video signal, the system automatically senses when too much light is present and adjusts itself accordingly, thus giving a continuous automatic control of the incident light. The operator does not have to worry about ambient light or light sources when operating the camera. If the sun comes from behind a cloud, the automatic iris repositions itself to take care of increased illumination and vice versa.

In order to bring the system into focus, the lens is preset and control over the camera position relative to the lens is remoted to the control tower. The camera rests on a small rail and moves relative to the three-lens turret by means of a remotely controlled electric motor and screw drive. It is necessary to accurately position the camera relative to the lens within 0.001-inch for focus purposes. Therefore, precision machine parts are required.

Camera Panning

The camera can be panned through a maximum of 350 degrees to control the azimuth and tilted ±45 degrees to control the elevation angle of the camera, subject to preset limit stops. The speed of pan and tilt can be varied by the operator so that an aircraft may be followed in flight or along the runway.

By means of pushbutton control, when a surveillance problem has been completed, the camera can be returned at high speed to its normal or "home" position predetermined by mechanical cams preset at the camera.

In the pan and tilt unit of the camera, in addition to the operating motors, sensing relays detect the position of the camera at any instant and control the direction of pan and tilt so that when the "home" button is depressed at the control tower, the camera will be returned to its normal position via the shortest possible route.

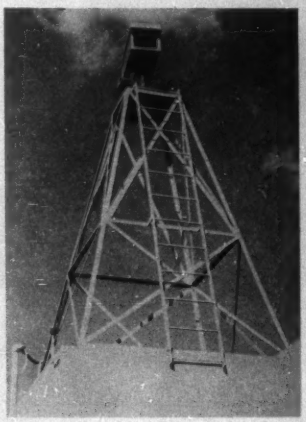
Multiple Controls

To perform these multiple control functions, three "robot" control centers are located within the building where each camera is located. Runs of camera cable from camera to camera control in this control center are always less than 200 feet. These control centers contain all the necessary control relays to perform the functions of pan, tilt, home, filter in-out focus, and lens selection. Each control center contains a full RETMA broadcast-type synchronizing generator which provides RETMA drive, blanking and sync pulses for the camera control deflection amplifiers. Each control center is equipped with a camera control which provides all the necessary operating voltages for the camera. These include the usual d-c supply voltages for a low-noise cascode video preamplifier in the camera, accurate interlaced deflection voltages and accellerating voltages for the vidicon tube in the camera. In turn, the camera control contains video amplifier with a gain of approximately 60 db which is especially designed to correct the video signal response of 8 megacycles.

Video Signal

For a typical camera chain, the video signal is amplified in the following sequence: (1) video preamplifier at camera, (2) video amplifier at camera control (60 db), (3) video line amplifier at Building 20 (10 db), (4) video line amplifier at control tower (10 db), and (5) video amplifier and sync separator in monitor.

For each camera system, there is a corresponding monitor in the control tower. The monitors are banked three side by side. A large metal adjustable canopy shade is provided to allow the operator to view the monitors in semi-shade so that no direct glare from the large windowed areas in the control tower will interfere with the visibility of the image on the television monitor. Large 14-inch rectangular picture tubes are used. All associated controls with each camera are brought out adjacent to the corresponding monitor. A 600-line horizontal resolution is realized at the monitor. Objects as small as 0.1-inch high on the television monitor are visible. Small aircraft are visible at distances up to 10,000 feet.



Official photograph, U. S. Navy

CAMERA atop hangar covers first 1,500 feet of runway, operates 43 feet above ground and can be panned east or west.

Portable Television Transmitter Is Used in Field Reconnaissance Work

THE ARMY now has a hand-held television camera and backcarried transmitter that a soldier-scout can use to send battle pictures to his command post.

Developed by the Signal Corps Engineering Laboratories, Fort Monmouth, N. J., the camera weighs a mere eight pounds. The transmitter or sending station, complete with built-in power supply, scales at 47 pounds.

By carrying his own battery pack, the camera armed television roving reporter is freed from the cumbersome cable connections that harnessed him to a source of power and limited his movements afoot as in earlier models.

The Signal Corps television cameraman can now reach previously inaccessible spots. He can move unhampered through protective forests and hedgerows, and over ditches.

Mission completed, the television scout can proceed to a new location taking his electronic eye with him.

The voice accompanying the picture could be handled by the Signal Corps handy walkie-talkie radio. In recent field tests at Fort Monmouth Laboratories, the camera and radio paired efficiently as reconnaissance eyes and ears.

Pictures up to a mile distant can be picked up by the flat cigar-box shaped camera and sent to a receiver another half mile away.

The camera has four interchangeable lenses including a wide angle one to view a broad sector, and a telephoto for far-away subjects. It has a pistol grip to help steady the camera and "pan" the action.

The Army's camera can also be mounted on a tripod for unattended operation. Surveying the battlefield, it could serve as a silent sentry to watch a road and report enemy movement. With artillery, it could cut heavy forward observer casualties by replacing them in exposed positions. It also could be used in helicopters to direct air-sea rescue operations.

The unmanned camera might be stationed in a suspected radioactive area, unaffected by gamma radiation that would endanger a soldier's life.

The sending station, which looks like a small suitcase, transmits pictures continuously for two hours. A five-cell rechargeable silver zinc battery, about one third the size and weight of a car battery is easily replaced in two minutes.

The television receiver with 10-inch aluminized picture tube is mounted in a jeep for fast mobility. The jeep's electrical system provides all needed power at the receiving point. Commercial power or regular household current, also can be tapped.

From the jeep the televised picture could be relayed to higher headquarters, or "piped" into a commercial television system.

The new Signal Corps camera can also be used with cable between transmitter and receiver. With power packaged in the transmitter, cable size is four times smaller than earlier models.

Push-button controls at his jeep console allows the television commander to monitor the pictures taken by five cameramen in the field. He can survey a battefield from various angles, just as a commercial television station covers a baseball game.

This latest television combat unit was built to Signal Corps specifications by Radio Corporation of America. Supervising the project for the Signal Corps is J. D. Jones of the Laboratories' Televisual Branch.

Radio Telescope To Disclose "New" Stars

Construction will begin late this spring on a new giant radio telescope which when completed will be able to detect celestial objects at distances close to the limits of the observable universe.

A grant of $48,000 from the National Science Foundation (NSF), Washington, D.C., to the Ohio State University electrical engineering department will provide for construction of the first half of the supertelescope.

It will be built on a site provided by Ohio Wesleyan University, Delaware, O., near Perkins Observatory, which is operated jointly by the two universities.

Eventual size of the radio telescope will be about 700 feet long by 75 feet high, making it the largest reflecting-type radio telescope in the world. Actually the telescope is a giant radio antenna, which receives radio emanations from the heavens much as an optical telescope receives light waves.

The antenna system will include a parabolic reflector unit and a flat, tiltable reflector to deflect radio waves from the sky into the curved portion, which in turn will focus the waves into a large metal horn. The horn will funnel the waves into an ultrasensitive receiver to be housed in a small

U. S. Army Photograph

U. S. Army Photograph

TACTICAL TELEVISION CAMERA and transmitter (above) with built-in batteries enables cameraman to move freely. The walkie-talkie operator makes up the two-man relay team, giving visual as well as descriptive information to the jeep-mounted monitor (*left*) with push-button controls. In emergencies, the receiver can be used in foxhole installations. The battery in the jeep engine supplies sufficient power for pickup. The unit operates on cable supplied current as well.

building. Surfaces of the reflectors will be metal screen, and the ground between the reflectors also will be covered by metal screen.

The telescope was designed by Dr. J. D. Kraus of Ohio State's electrical engineering faculty, director of the university's Radio Observatory. Studies and scale-model tests of the device have been under way for two years.

First stage of the telescope will measure 350 feet long by 75 feet high.

Because of the design of the telescope, it is expected to locate "thousands" of new radio stars. He explained that because radio waves are millions of times longer than light waves, radio telescopes need to be much larger than optical instruments in order to resolve, or single out, objects in the sky. A huge "aperture" will result in greater range and higher resolution.

The supertelescope will be of a "meridian transit" type, able to receive waves from any point along a North-South line but scanning in the East-West direction only through the earth's rotation.

The telescope will operate on wavelengths in the range of 1 meter or less to 10 meters. A scale model of the telescope, measuring 12 feet across, has been built and is now in operation on the roof of Ohio State's Electrical Engineering Building, receiving celestial radio waves at a wavelength of 1 centimeter. Tests on the scale model have been used to predict performance of the full-size antenna which will be a pioneering step in the direction of super radio telescopes of the same design.

The estimated cost of a unit of the same design, measuring 2,000 feet long by 200 feet high, would be about $1 million and would penetrate still deeper into the remote reaches of the universe.

Work in radio astronomy at Ohio State has been in progress since 1952 under the direction of Dr. Kraus. The grant is the third received from the NSF in three years to assist in the university's radio astronomy work. Earlier grants were for $9,800 and $23,000 for radio mapping studies of the sky and for scale model tests of the new telescope design, respectively.

AA Defense Improved by Army's New Missile Master System

MISSILE MASTER, the country's first electronic system designed specifically for controlling and co-ordinating the use of NIKE antiaircraft missile batteries and other advanced Army weapons as they become available has been announced jointly by the U. S. Army and Glenn L. Martin.

Development of this type system was started in 1945. In 1950, a forerunner of Missile Master was designed. It was installed at Fort George G. Meade, Md. about two years ago. Systems being built will be located at key antiaircraft installations in the United States. Each system operates independently, and can also operate in conjunction with units of the recently announced Air Force semi-automatic ground environment area defense system, known as SAGE. (See *Electrical Engineering*, March 1956, page 305.)

Co-ordinates and Directs NIKE Batteries

Missile Master is a complete electronic system for the co-ordination and direction of a large number of NIKE guided missile firing batteries.

The system collects information on the location of aircraft and their identity, presents this information on electronic displays, and distributes these data to the missile firing batteries. In this way, each NIKE battery receives a continuous flow of fresh data on all aircraft within the defense area, and on the activities of the other batteries as well; and each NIKE battery commander is provided with all the information needed to enable him to make a proper selection of a target. In addition, Missile Master operators observe the activities of all batteries in the system and, where necessary, are able to direct a specific fire unit to a particular target, or to prevent friendly aircraft from being fired upon by our own weapons.

The system is the first to unify all elements of antiaircraft missile defense from target detection to target destruction. Each unit consists primarily of an automatic data communications network, and of automatic data processing and display equipment. The system is designed to achieve the maximum effectiveness in firings of all NIKE and other antiaircraft weapons from any given installation.

Army officials say that experiments with the system at Fort Meade, and other related tests and investigations, have amply demonstrated the ability of Missile Master to co-ordinate and control a large number of antiaircraft batteries more effectively than ever before against a large number of aerial targets.

Key personnel of Missile Master are: the tracking operators, who monitor early warning information as it enters into the Missile Master system; tactical controllers, who evaluate the progress of an engagement and assign specific targets to batteries as may be necessary; the "friendly protector," who insures that NIKE batteries do not fire on known friendly aircraft; and the battery commanders able to select or receive target assignments without conflicting with or duplicating the actions of other batteries.

Display Consoles

Each Missile Master operator has a display console of some form. Target information appearing on the consoles of tracking operators is displayed with distinctively shaped markers to indicate different categories or targets.

Future Meetings of Other Societies

NEMA, 1st National Farm Wiring Conference, May 3–4, LaSalle Hotel, Chicago, Ill.

Pennsylvania Electric Association, Hydraulic Power Committee Spring Meeting, May 3–4, Hotel Warwick, Philadelphia, Pa.

AIChE, National Meeting, May 6–9, New Orleans, La.

Pennsylvania Electric Association, System Planning Committee Spring Meeting, Hotel Alexander, May 7–8, Hagerstown, Md.

Air Conditioning and Refrigeration Institute, Annual Meeting, May 7–9, The Homestead, Hot Springs, Va.

ASME, joint Metals Engineering Division and American Welding Society National Spring Meeting, May 7–13, Hotel Statler, Buffalo, N. Y.

NACE, Northeast Region Meeting arranged through Niagara Frontier Section, May 9–10, University of Buffalo, Buffalo, N. Y.

Research and Engineering Council, 6th Annual Meeting, May 9–11, Edgewater Beach Hotel, Chicago, Ill.

American Institute of Chemists, Annual Meeting, May 9–11, Hotel Statler, Boston, Mass.

Atomic Industrial Forum, Southwest Research Institute of San Antonio, May 10–11, San Antonio, Tex.

Pennsylvania Electric Association, Transmission and Distribution Committee Spring Meeting, May 10–11, Skytop Lodge, Skytop, Pa.

Operations Research Society of America, 4th Annual Meeting, May 10–11, Sheraton-Park Hotel, Washington, D. C.

Joint Electron Tube Engineering Council, 4th General Conference, May 10–12, Traymore Hotel, Atlantic City, N. J.

Verein Deutscher Ingenieure, Centenary Celebration in Berlin, May 12–15, V.D.I., Prinz-Georg-Strasse 77/79, Dusseldorf, Germany.

Pacific Coast Electrical Assn., Inc., Annual Convention, May 14–16, Las Vegas, Nev.

National Research Council, Conference on Basic Mechanisms in Radiobiology, May 14–16, Highland Park, Ill.

IRE, National Aeronautical and Navigational Conference, May 14–16, Hotel Biltmore, Dayton, Ohio.

ASME, Design Engineering Conference, May 14–17, Convention Hall, Philadelphia, Pa.

Industrial Nuclear Technology Conference, May 15–16, Museum of Science and Industry, Chicago, Ill.

Mechanical Contractors Association of America, Heating, Piping, and Air-Conditioning Contractors National Association Annual Meeting, May 15–18, The Kentucky Hotel, Louisville, Ky.

Pennsylvania Electric Association, joint Electrical Equipment and Relay Committees Spring Meeting, May 17–18, Hotel William Penn, Pittsburgh, Pa.

New York State Professional Engineers, 30th Annual Convention and Exposition, May 17–19, Statler Hotel, New York, N. Y.

Industrial Heating Equipment Association, Inc., Spring Meeting, May 20–23, The Homestead, Hot Springs, Va.

RETMA, Symposium on Reliable Applications of Electron Tubes, May 21–22, Irvine Auditorium, University of Pennsylvania, Philadelphia, Pa.

American Association of Railroads, Communications Section Convention, May 22–24, Netherlands Plaza Hotel, Cincinnati, Ohio

National Warm Air Heating and Air Conditioning Association, May 22–25, Edgewater Beach Hotel, Chicago, Ill.

National Society of Professional Engineers, Annual Meeting, May 23–26, Ambassador Hotel, Atlantic City, N. J.

Pennsylvania Electric Association, Systems Operation Committee Spring Meeting, May 24–25, Bedford Springs Hotel, Bedford, Pa.

Armed Forces Communications and Electronics Association, 10th National Convention, May 24–26, Statler, Hotel, Boston, Mass.

ASTM, 4th Conference on Mass Spectrometry, May 27, Netherlands Plaza Hotel, Cincinnati, Ohio

THESE radar entry consoles in the system at Fort George G. Meade, Md., are similar to the electronic consoles which are the heart of the Missile Master system. Operators use photoelectric light guns placed against the screens to enter targets into the electronic tracking system.

Tactical controllers have special displays which, with numbers and symbols, give all pertinent information on targets and on battery actions. Switches enable controllers to view general, or particular marker information on their screens at any given moment.

Target position information passes directly into the Missile Master tracking subsystem and is displayed on the consoles of tracking operators. Information consists of position, identity, and velocity data, the size of the target and the priority of the target in cases where a priority has already been assigned.

Target information available to the SAGE system is passed on to Missile Master. When SAGE information is unavailable, Missile Master tracking operators are able to generate data of their own from the local surveillance radar.

In either case, the data is stored electronically and distributed to all display consoles in the Operations Center and at the batteries.

Tactical controllers monitor the air situation and target selections by individual batteries, but can intervene to assign targets to individual batteries for quick engagement, or to terminate engagements to avoid duplication.

During engagement of targets, the "friendly protector" watches the position of all known friendly targets and compares this information with the engagement data returned from battery commanders to halt the possible individual engagement of any friendly target.

Target Engagement Sequence

With the approach of hostile targets, identity and other information on targets begins coming in and is displayed on the various consoles in the Operations Center and at the batteries. The tracking operators make sure that the positions indicated by SAGE correspond to the position of the targets as actually seen on the local radar—and establish tracks on those targets not already being tracked by SAGE. The tactical controllers monitor the progress of the engagement, as hostile targets approach close enough to be fired on by NIKE's and insure that targets are engaged in the most effective manner.

Electronic Autopilot Controls Supersonic Flight

A new Super Sabre Jet—the F-100D—that can fly itself to a target has been flown for the first time by test pilot Dan Darnell, it was announced recently by North American Aviation, Inc., Los Angeles, Calif.

The new model of the Air Force's first fighter bomber capable of exceeding the speed of sound in level flight incorporates a Minneapolis Honeywell autopilot, first system developed expressly for a supersonic jet.

This electronic device—definite forerunner of complete automatic flight—will control the F-100D at supersonic speed enabling the pilot to concentrate on navigation or other tactical phases of his mission. The autopilot is said to relieve pilot fatigue and greatly reduce chances for human error in split second timing required at these speeds.

Outwardly similar to other models of the F-100 now in service with Tactical Air Command units, the F-100D incorporates several improvements to help it do a better job in its assigned mission as a fighter-bomber.

Like earlier "A" and "C" models the new fighter will be powered by a Pratt and Whitney J-57 turbojet engine with afterburner. Its performance will be comparable to the Air Force F-100C which streaked across the Mojave Desert at an 822.135 miles an hour clip to set an official world's speed record.

It is 47 feet long, 15 feet high, and its 45 degree swept wings have a span of 38 feet. Equipped with a probe and drogue in-flight refueling system the F-100D can escort high speed bombers on long missions or strike by itself against distant targets.

Faster D-C Motors and Generators Developed

To meet modern industrial needs for faster, more continuous, more automatic production, General Electric (GE) has announced an entirely new line of d-c motors and generators.

The new Kinamatic (GE trademark) line is the result of a comprehensive engineering study made by GE to determine modern industry's drive requirements.

The Kinamatic line is the first complete line of industrial d-c motors and generators built to the latest NEMA standards for future design. All motor ratings from 1 to 150 hp and all generator ratings from 3/4 to 100 kilowatts are available.

The d-c Kinamatic motor can be applied where extra power at high speeds is needed. Through "forcing"—the application of overvoltage—many ratings can operate at proportionately higher speeds and horsepower. When properly applied, the d-c Kinamatic motor can operate at any speed below base speed, including stalled torque. This low speed performance is especially important for process changes, threading and setting up operations, and adjustable speed duty cycles.

Faster speed of response is made possible by a significant reduction in armature inertia (Wk^2) and electrical time constant permitting split-second response for quick stops and starts and fast reversals and speed changes.

Peak commutation, to take safely the short bursts of power necessary for quick acceleration and deceleration, has been built into the d-c Kinamatic motor. Fewer turns per armature coil assure minimum inductive kick when stored energy is released from the coil. A full complement of commutating poles permits greater overloads without magnetic saturation.

Full Class *B* insulation, a high volume fan, and improved air flow guarantee a 15% service factor in all standard dripproof Kinamatic motors. Users can take advantage of this in three ways: to obtain 15% more than rated power continuously for normal life of the motor, obtain longer motor life at rated power, and obtain greater versatility on speed and horsepower duty cycles.

D-c motor maintenance is reduced and simplified in the Kinamatic motor. Brushes are easily accessible through large hand holes. The brush spring may be quickly disengaged with one hand, then hangs captive to the brush holder but clear of the brush for easy replacement. Brass brush holders and molded polyester glass yokes provide a rugged, corrosion-resistant brush rigging assembly. Ball bearings are packed with a special GE lubricant which will last many years under normal operating conditions. Conveniently located grease fittings permit relubrication without disassembly of the motor. Split, cast iron, waterproof conduit boxes, available in three sizes for each motor frame, provide ample room for wiring connections. The standard d-c Kinamatic motor has a rolled steel frame with cast iron dripproof endshields. An eyebolt is provided on all motors for safer, easier lifting. An average of 33 per cent increase in horsepower per pound has been achieved.

Lower inventories of spare motors and spare parts are possible with the Kinamatic motor because its greater versatility permits switching motors from one application to another.

A complete line of accessories and modifications adds greater versatility to the motor. Designed to handle changes in user's requirements, all accessories can be added to the standard motor. In many cases this will reduce the need for "specials."

Research Positions in US-IGY Antarctic Program

Opportunities for physical scientists, engineers, and technicians, exist in the Antarctic program planned by the U. S. National Committee for the International Geophysical Year (IGY), 1957–58. The IGY is an unprecedented study of the physics of the earth in which more than 40 nations are collaborating. The U. S. Antarctic program emphasizes the following fields: aurora and airglow, cosmic rays, geomagnetism, glaciology, gravity, ionospheric physics, meteorology, and seismology.

Major geophysical research stations will be established at Little America, Marie Byrd Land, the South Geographic Pole, on the Knox Coast, and along the Weddell Sea. Initiation of this program began last year with the site-reconnaissance voyage of the *U.S.S. Atka*. "Operation Deepfreeze," currently under way, will establish the Little America Station, cache supplies for the interior stations to be set up in the fall of 1956, and explore site possibilities for stations on the Knox Coast and the Weddell Sea.

The scientific program will cover slightly over two years from January 1956 to April 1959. Scientists and technicians will leave the United States about November 1, 1956. Positions are open for either the full period of investigations or for the two periods November 1956–April 1958 and November 1957–April 1959. Prior to departure approximately two months of advance training will be provided in problems of research, instrumentation, and operations in the polar regions.

Opportunities are available to candidates at the bachelors, masters, and doctorate levels of training and experience. Scientists, engineers, and technicians, with training in physics, geophysics, electronics, or closely allied areas and interests in the fields of study enumerated, are invited to address inquiries to the National Academy of Sciences, United States National Committee for the International Geophysical Year, 2101 Constitution Avenue, N.W., Washington 25, D. C.

Another part of the US-IGY program is the Technical Panel of the Earth Satellite Program. Dr. Joseph Kaplan, chairman, U.S. Committee for the IGY, has announced the membership for this project. The eight-member Panel will have fundamental responsibilities for the development, coordination, and direction of the over-all scientific satellite effort.

Breakthrough Made in Releasing Sun's Stored Energy

Air Research and Development Command (ARDC) scientists have achieved the first step in unlocking the vast storehouse of energy in the high upper atmosphere.

An Aerobee rocket equipped to release nitric oxide gas under high pressure was sent to an altitude of 60 miles above the desert of Holloman Air Development Center, New Mexico, and accomplished a breakthrough that has been the subject of speculation by geophysicists for the past 10 years—releasing the energy chemically stored by the sun in the upper atmosphere.

When the nitric oxide gas was automatically released, observers saw what first appeared to be the formation of a new star, nearly twice the brightness of the planet Venus.

The light was reported by observers more than 60 miles away from the ARDC launching site.

In less than 10 minutes the "star" had grown in size so as to appear to an observer on the ground to be about four times the diameter of the moon.

By increasing the natural amount of nitric oxide in the atmosphere by a factor of several billion, the released gas was able to unlock the chemically stored sunlight in vast quantities. This action produced the spot of light in the upper atmosphere which spread to approximately three miles in width before the nitric oxide gas thinned out and reduced the brightness of the light.

Although the spreading of the light was visible to the naked eye for approximately 10 minutes, sensitive instruments at observation stations on the vast Holloman range were able to detect the light for a much longer period.

The scientists of the Air Force Cambridge Research Center discovered in the laboratory that energy locked in atomic oxygen could be released by the addition of a gas containing one atom of nitrogen and one atom of oxygen. Chemically, this combination is known as nitric oxide (NO).

Nitric oxide has the property of bringing two oxygen atoms together to form an oxygen molecule and release light. The gas is not used up in the process, but is used over and over again without being exhausted. The process occurs naturally in nature, but the natural abundance of nitric oxide gas is so small that its natural glow in the sky must be detected at night by instruments which are many times more sensitive than the naked eye.

Electrically Powered Earth Hauling Truck

THE ENGINEERING DEPARTMENTS of Kenworth Motor Truck Company, General Electric Company, and Riverside Cement Company have designed an electrified end-dump truck (802-E), which is powered by electric traction motors and receives current from overhead wires through a trolley. The truck also is equipped with a cable reel so the operator can maneuver away from the overhead wire zone. In a limestone quarry, the trucks move rock from an underground mine to a crusher on the surface. This limestone haul is nearly a mile long, about half of this distance being entirely underground on a 10 percent grade to the surface. The 550-volt main traction motor has been placed where the transmission would be located in a diesel-powered truck. An auxiliary 550-volt motor is located under the hood to power air compressor, power steering, hoist pump, and the lighting system. For ease of maintenance, electrical controls are centralized in a box to the driver's right. Driver protection has been considered throughout the 802-E's electrical design. A limit switch prevents moving the truck when the body is being raised for dumping. Pressure switches prevent power from being taken from trolley poles when poles are in the retracted position.

Scientists have known for many years that if they could find some way for the separate oxygen atoms to combine together rapidly, a light many times stronger than natural light in the atmosphere could be emitted. The light thus produced is actually sunlight which has been stored chemically in the oxygen atoms and can now be released.

The experiments may eventually lead to a means of extracting this energy for such uses as the propulsion of rocket ships high in the earth's atmosphere.

Another "first" scored by the ARDC scientists came on March 12, when a preliminary Aerobee flight was launched releasing nitric oxide gas during daylight. This test was to observe the ability of sunlight to react on the nitric oxide gas during the daytime. It was found that the action of the sunlight on the gas produced an artificial cloud of charged particles which reflected radio waves in the same manner as the ionosphere.

The ionosphere is the layer of the earth's atmosphere that ranges from an altitude of about 50 miles to 250 miles. It has been found that radio waves are reflected (or "bounce") from the ionosphere and allow long-range communication.

During the experiment, scientists "bounced" radio signals from the charged cloud in the same way that light is reflected from a mirror. They feel that man made ionospheric clouds produced in a series may pave the way for increasingly effective long-range communications.

Atomic Clock Displayed at IRE Show

Among the more dramatic displays at the IRE (Institute of Radio Engineers) Show, held at the Kingsbridge Armory, New York, N. Y., March 19–22, was the "Atomichron," the first commercially available atomic primary frequency standard.

This so-called "atomic clock," developed by the National Company, Malden, Mass., offers a stability of frequency, over extended periods, of 5 parts per 10 billion or more, and its accuracy is limited only by the limitations of presently accepted methods of measuring time. The new instrument is expected to have widespread applications in research, development and control because of its unprecedented stability. It will thus find ready application as a Primary Frequency Standard.

In electronic research and manufacturing, the reference standard may be piped to various places in the laboratories or the test and assembly lines. It is the most accurate and stable calibrating instrument for oscillator crystals and offers a stability of 5 parts in 10^{10} parts as an elapsed-time measuring instrument. The "Atomichron" also provides a means of communications monitoring and control, which permits the design of receivers and transmitters of such narrow and precise bandwidth that it becomes possible to obtain at least double the utilization of the presently crowded spectrum.

This equipment is said to be superior to the finest existing by at least a whole order of magnitude. It is a self-monitoring system, readily installed and with a wide variety of applications already existing.

The instrument's operation is based on the phenomenon that an uncharged cesium atom, when subjected to an R. F. field at 9192 + mc, is likely to change energy level. By multiplying the output of a 5 mc primary crystal frequency standard to the resonance frequency of cesium, then measuring the rate of changes in energy level of cesium atoms in the R. F. field, it is possible to monitor and correct the output of the 5 mc oscillator to an accuracy of 1 part in 10^9, and to maintain a stability of the 5 mc signal within 5 parts in 10^{10} parts over extended periods.

This same degree of accuracy and stability is achieved on all the output channels of the Atomichron: 100 kc, 1 mc, 5 mc, 10 mc, and 100 mc. Output signal level is 10 dbm on all channels.

Annual Report Is Issued by ASA

The annual report of the American Standards Association (ASA) issued by Vice-Admiral G. F. Hussey, Jr. (Ret.), managing director, marked 1955 as the "biggest year for standards" in the history of the 37-year old organization.

The ASA approved 238 American Standards from January 1955 to January 1956. This contrasted with 153 American Standards approved in 1954. The Association approved 21 standards related to the electrical and radio fields.

There are 388 projects for standards being carried on under ASA auspices at present. One of these projects, standards for centrifugal pumps, when completed, will save the chemical industry alone an estimated $6.8 million annually. The oil industry calculates savings of between 50 and 100 million dollars annually by using the standards.

Expanding economy in the United States is making heavy demands on the ASA. To cite an example, ASA has been approached by one of the major associations in the field of home building to discuss providing an immediate program of standardization for material, supplies, and equipment that go into residential structures. This industry has put up well over one-million houses each year since 1949 and the rate is expected to continue or even accelerate.

If standard dimensions are used, the building industry can save $1 billion annually. This estimate evolved from the "House and Home" round table discussions held last year with representatives of the construction field.

Progress in the planning of standards for nuclear energy processes, an undertaking begun by industry through the ASA in December 1955, was announced at the same time.

It was also pointed out that saving lives of children was accomplished with the completion and recent adoption by the paint industry of the American Standard for reducing lead content of paints.

In international standards work it was stated that France still leads the world and the United States falls 13th in line. However, the United States took up at least observer status last year in all the projects of the International Organization for Standardization (ISO) through the ASA, and sent to ISO meetings more delegates—90 persons—than at any time in history.

There was a marked increase in ISO participation by satellite countries, such as Czechoslovakia, Poland, Hungary, and Rumania. Russia led the United States by a 20 per cent margin in international standards work. In 1954, the United States lagged 15 per cent behind Russia in degree of participation.

Admiral Hussey added to the report the availability of American Standards in 46 other countries. He pointed out the advantages to the United States in world trade to make products according to American or international standards in which the United States participates.

Impact of Atomic Energy on Chemical Industry Announced

A survey of 75 chemical companies regarding the impact of peaceful uses of atomic energy on that industry shows that changes will be "evolutionary rather than revolutionary." The companies polled include many engaged in nuclear research and some in actual production operations.

The survey, made public by the Manufacturing Chemists' Association (MCA), also stated that new chemical markets will result from by-products of nuclear processes; that greater use of nuclear energy may mean that products not now produced commercially will be needed in tonnage quantities and, barring a national emergency, new nuclear facilities can now be built without worrying about shortages of scarce materials.

The consensus was that recent declassification efforts by the Atomic Energy Commission (AEC) is providing more freedom of operation to private enterprise but that further declassification of material would assist the progress of peaceful uses of atomic energy.

An interesting sidelight on the basic problem is that of insurance. The chemical companies reporting called insurance cover-

age for nuclear installations "a real problem," not only for the chemical industry but all industries concerned with nuclear development.

Artificial Respiration Two-for-One Method Devised

A method of artificial respiration which makes it possible for one operator to give aid to two victims at one time has been tested and found effective by the University of Nebraska College of Medicine in Omaha.

The new "two-for-one" system has been thoroughly evaluated by the Physiology and Pharmacology department under the direction of Dr. A. L. Bennett. In general, they found this method to be essentially as effective as the official method now in use for single victims and to require very little more effort on the part of the operator.

The method used is a modification of the Holger Nielsen or back-pressure arm-lift method. The idea for the procedure was first suggested and demonstrated by M. M. Mehring, safety supervisor of the Consumers Public Power District of Nebraska. Mr. Mehring felt the need for such a procedure for there are cases where one hot wire will shock two men working together. Usually there may be only one other worker in the area, so the question has been which man to try to save.

When a multiple drowning, asphyxiation, or electric shock emergency arises, the rescuer must first place the two victims in a prone position (on their stomachs) with the inner arm of each person extended straight beyond his head. Each outer arm should be bent at the elbow and placed so that each out-turned face rests at the temple across the back of a hand. The rescuer or operator, in a kneeling position, straddles the extended inside arms of the victims. Next he places one open hand on each subject and rocks slowly forward, applying about 35 to 40 pounds of pressure on the back of each adult subject.

After gently releasing pressure on the back, the rescuer then grasps the outside elbow of each subject and rocks backward while he pulls on the elbows just enough to roll the outer edge of each chest from the ground. The respiration cycle is completed by dropping the arms. Complete respiration cycles are continued at the rate of 12 times per minute or one complete respiration every five seconds.

Xerographic Process Used for Printed Circuit Etching

The preparation of printed electrical circuits for etching can now be done by xerography, The Haloid Company of Rochester, N. Y. has announced. The new process promises spectacular savings in time and money for model shop work, prototype circuit studies, and short production runs.

In the new application, the powder image peculiar to xerography—a fast, dry, electrostatic method of copying, heretofore used chiefly in office and graphic arts reproduction—is transferred from a XeroX (trade mark) selenium plate to a sheet of transfer paper, thence to the face of a copper-clad laminate. Here the powder forms a photo-exact resist pattern impervious to chemical attack.

Because, in the etching step which follows, acid eats away all the copper unprotected by resist, the result is metal left only where specified by the original circuit drawing. The xerographic powder or resist, having accomplished its purpose, is then removed by solvent, disclosing the completed print ready for dip-soldering to "pig tails" or other contacts.

From an original opaque drawing, a copper-clad laminate serving as a printed circuit or wiring board can be prepared for etching in about 10 minutes. This time is approximately nine times faster than that of the photo-resist method and about 14 times faster than silk screen, the only other processes in common use. Except for the final etching step, the xerographic approach is entirely dry, requiring neither conventional photographic materials nor darkroom facilities.

In most cases, because printed circuits are generally small, several identical circuits may be made from one xerographic exposure. The number possible from one cycle depends on the size of the circuit to be produced and the sensitive area of the selenium plate.

Flying Safety Test Program Instituted

The Air Research and Development Command will participate in a joint test program to determine accurately the magnitude of altimeter system errors existing in various models of military and civil aircraft.

The program has been instituted as a result of recommendations by the Radio Technical Commission for Aeronautics. Altimeter system errors are believed to be the primary reason for the increasing number of near misses reported by pilots flying assigned altitudes with 1,000 foot separation.

Although there are effective standards pertaining to the accuracies of altimeter instruments and static pressure installations, the problem of error has become acute. Higher operating altitudes of aircraft, increased volume of aircraft, increased speed ranges, and improved precision of radio navigation aids with concentration of air traffic within narrow flight lanes have created a necessity for the current program.

ARDC will furnish Air Force information on altimeter error for fighter, bomber, and transport aircraft. Pacer aircraft, whose altimeter systems have been precisely calibrated, fly with another airplane and gather error data at various speeds and altitudes.

Normally only early production models of aircraft are calibrated for altimeter system error. Later production models may pickup errors to ±2.0 per cent. Under these conditions, pilots flying the 1,000 foot separation face the danger of midair collision as they may not actually be flying at the altitude shown on their instruments.

In addition to conducting the tests at its Wright Air Development Center and Air Force Flight Test Center, ARDC will calibrate pacer aircraft for use by each of nine civil airlines. The Air Transport Association will co-ordinate the use of military facilities for the civil airlines. All agencies are certain that an important contribution to increased safety in the air will be made when the program reaches a successful conclusion.

Giant Brain Links Units for Data-Processing

Newest achievement in the rapid evolution of electronic computing systems from the *Mark I* of World War II days was unveiled recently by Datamatic Corporation of Newton Highlands, Mass. Called the "Datamatic 1,000," it is a co-ordinated data-processing system employing high-speed computer principles to speed all phases of record-keeping and accounting.

The Datamatic system is described as a highly efficient electronic office capable of handling a wide range of clerical operations, from accounting and billing to sales analysis, inventory, and production control. Thus, with special magnetic tapes, there will be no broken fingernails or frayed tempers searching through filing cabinets in tomorrow's deluxe office. In addition, the system provides management with continuous compiling and processing of reports upon which daily business decisions are made. It is designed for sale to both business and Government.

Data for the new processing system is fed, in the form of punched cards, into an input converter (a special transcription device), which translates, edits, and transcribes the data onto three-inch-wide magnetic tapes at the rate of 900 cards per minute. One reel of tape (2,700 feet) can store 37.2 million decimal digits of information—or the equivalent of information contained on 465,000 punched cards.

The central "brain" can "read" and "write" at the rate of 60,000 digits per second, simultaneously handling 1,000 multi-

BOB WILKINS, Datamatic engineer, threads a giant spool of tape in one of the system's 100 file units. This single, 2,700-foot spool can store as much data on its 31 channels as could be found on about a half-million punched cards.

plications, 4,000 additions, or 5,000 comparisons. The new processing system can also search 10 files simultaneously within 11 minutes to find any specific data.

One magnetic tape file unit in the Datamatic system can handle (read, write, or file) as much information as some of the older systems can store altogether. The system's building-block arrangement permits the incorporation of as many as 100 tape units, any one of which can be referred to or questioned without disturbing the rest of the system.

Final reports are turned out at the rate of 6,000 punched cards per hour or 900 printed lines of report per minute.

Industrialists and Educators Form Career Training Council

Formation of a joint industrial and educational team dedicated to the solution of America's most critical defense problem—the acute shortage of scientists, engineers, and skilled technicians—was announced in New York, N. Y.

The new body, organized on a New York State level but with national affiliations, will serve as a clearing house in the exchange of techniques, ideas, information, and teaching personnel.

A nonprofit service organization, it will be known as the Career Training Council (CTC). Its first officers and advisory board members include men associated with some of the nation's leading industries and educational bodies.

The CTC's prime purpose will be to help overcome, as swiftly as humanly possible, the critical shortage of skilled man-power in fields such as electronics, atomics, jet propulsion, communications, and automations, because unless the problem is solved quickly America will find itself out-stripped and outmanned.

One of the Council's first major ventures was the sponsorship of Career Week March 18 through 24. Its high-spot was the Career and Job Show March 23 and 24 in the 71st Regiment Armory, 34th Street and Park Avenue, New York, N. Y.

Major defense industries present visually demonstrated their technical operations and sought to recruit new technical personnel on the Armory floor. Admission was free to college and trade school students and graduates, as well as the general public.

Some of the things the CTC will do are:

1. Determine industry's future needs and project teaching growth as far in advance as 10 years from now.
2. Explore the various methods of teaching the teachers who will train the future students.
3. Pass along information, learned from pilot courses, to all colleges and trade schools, through the New York State Education Department.
4. Help initiate new courses at vocational schools throughout the State, to fill industry's needs.

Other phases of the Council's program will include: public education, aimed at America's youth, to convey the advantages of technical careers; establishment of speaking bureaus to carry this message; obtaining grants from industry for scholarship and teaching methods research; sponsorship of an annual Career Week and a Career and Job Show; providing a common mass meeting point for industry and technical personnel.

Miniature Pattern for Typotron Placed in Nickel 0.0001-Inch Thick

A pattern of digits and letters only 0.012-inch high has been successfully placed in nickel 0.0001-inch thick, supported by beryllium copper foil which is 0.0015-inch thick, by the Industrial Division of W. and L. E. Gurley, Troy, N. Y., manufacturer of binary code discs and other optical components for the electronic industries.

The pattern is produced in a matrix which is placed in the electron gun of a typotron tube and make possible the formation of shapes of letters and other characters on the face of the tube. Approximately 25,000 characters can be displayed every second with the typotron.

Gurley electro-formed the characters in the matrix by nickel plating on a beryllium copper base.

After the image is formed in the nickel, the beryllium copper is removed from behind the characters by electro-etching, so that the image remains in sharp detail. The remaining beryllium copper serves as a supporting medium for the nickel mask.

Public School Closed Circuit System Operating

Gov. R. E. Smylie of Idaho today conducted a class in political science at Idaho State College which was witnessed simultaneously over television by youngsters in 11 different elementary schools in the nation's first demonstration of a completely "televised" public school system.

The governor and other state officials participated in a panel discussion on state government. They were interviewed by six students who are members of the high school state government class. Also televised was a fourth-grade reading and social studies class watched by fourth graders and student teachers. A third class was conducted by Lt. A. Nogo, Idaho State Police, demonstrating the use of radar in highway safety.

The closed circuit educational network, which was set up at a cost of $7,500, was financed jointly by the Jerrold Electronics Corporation of Philadelphia and Bannock Cable Television, Inc., of Pocatello.

The community antenna system which brings three television channels into Pocatello is operated by the latter company. Signals are picked up on an antenna tower and delivered to subscribers via coaxial cable. Jerrold Electronics engineered, manufactured, and installed the equipment. The two companies recently made a grant of $5,000 to Idaho State College for the purpose of establishing the chair of television coordinator to head the educational network.

The college studio is connected to the community antenna system so that educational programs can be watched by youngsters and parents right in their own homes.

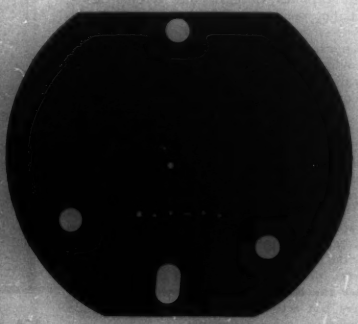
Though many universities have experimented with closed-circuit television within their campus buildings, Idaho State is the first college in the country to install a complete public school network.

The new network makes it possible for a few specialized teachers who formerly traveled from school to school to reach a much larger student body by broadcasting from the Idaho State College studio.

Visual aids such as films and slides will be shown on the 21-inch television sets in the special classrooms set aside for television teaching. That means a single film library can be set up in the college studio. Money formerly spent on duplicate films and equipment will be used to enlarge the library.

It is expected that students will originate many of their own programs, such as plays, special musical events, panel discussions, and news broadcasts.

Present plans also call for the extensive use of television for teacher-in-service training. College faculty members will give teaching demonstrations. The superintendent of public schools and other administrators intend to conduct faculty meetings via television, too.



MICROSCOPIC INSPECTION (left) of matrix for typotron tubes insures perfection of miniature characters. Enlarged view of matrix (above), carrying digits and letters 0.012-inch high, placed in nickel 0.0001-inch thick.

Mobile Color "Studio" for Lease to TV Stations

A new television service which will enable broadcasters in various areas to originate colorcasts of local events through the facilities of an RCA color television "studio-on-wheels" was announced recently by the Radio Corporation of America (RCA).

The service will permit television stations modified for color transmission to lease an RCA color television mobile unit completely equipped with video and audio facilities and two "live" studio cameras. The mobile unit, for origination of color programs in the field or station, will be operated by station personnel.

The first RCA color mobile unit will be available to television stations within a 150-mile radius of Philadelphia, Pa. It is anticipated that additional units will be added at a future date to extend the mobile service to other major television centers.

This "studio-on-wheels" concept has been developed to provide stations with a practical, economical means for originating colorcasts of important local events. Pending installation of permanent origination equipment, the RCA color mobile unit will enable such stations to improve their service to viewers and sponsors and to acquaint engineering and programming personnel with equipment and techniques for local colorcasting. The RCA color television mobile unit, can be utilized also to augment the facilities of stations already equipped for origination. Programs originated by the mobile unit can be transmitted nationally.

The "studio-on-wheels" equipment consists of two RCA *TK-41* live color camera chains; a *TS-71A* switching system; a *BC-4A* audio console; color synchronizing equipment; color test equipment; and cable for operation of the cameras up to 250 feet from the mobile unit. Broadcast microwave equipment can be installed as accessory equipment for applications involving long-range transmission of color pickup from camera to station transmitter. Storage compartments are provided for transporting more than 2,000 feet of cable.

In addition, RCA will provide the services of two engineers to instruct and supervise station personnel in the set-up and technical operation of the equipment.

The mobile unit, featuring a custom-built chassis and body, is divided internally into operating and storage areas. The operating area houses all control equipment. The "studio-on-wheels" also includes a heating and air conditioning system.

The color TV mobile unit measures 28 feet long and 12 feet high, is equipped with power steering and air brakes, and features a steel-reinforced 6- by 16-foot roof section for mounting microwave and associated accessory equipment. The colorful unit is delivered to customer complete with station call letters and channel number.

One of these "studios" has been purchased by Smith, Kline, and French, including a 3-Vidicon live color camera chain recently developed for specific use in colorcasting surgical and clinical demonstrations. The Philadelphia pharmaceutical firm will utilize the mobile unit for presentations at surgical and medical meetings, as well as local or network broadcast.

100-Million Tons of Ilmenite Discovered in Norway

A Canadian-developed and produced magnetometer has discovered more than 100-million tons of good quality ilmenite in southwest Norway. This valuable ore is used in the making of jet engines, paints, and other products. The find has been christened the Telines deposit.

PSC Applied Research Limited, of Toronto, Ont., Canada, developed and manufactured the instrument for use by other Hunting Group companies, and their clients. It was used in the finding of this large deposit by Hunting Geophysics Limited, of England.

The aeromagnetic survey of some 300 square miles in Norway's southwest was begun last year for the well-known mining company, Titania A/S of Sokndal.

Although the ordinary compass would make one think the earth's magnetic field always lies exactly north and south, it usually does not. Deposits of ore in the ground twist it, and this twist is measured by a magnetometer mounted in the tail of the aircraft as it flies up and down over the area to be surveyed.

A team from a sister company, Hunting Aerosurveys Limited, first photographed the area, and a mosaic of vertical aerial photographs was constructed so as to insure pinpoint navigation for the mineral-hunting aircraft.

This survey is of special interest in that it is the first in Europe whose results have been made public. The science of airborne geophysical survey is comparatively young, and all such activities are security-bound until the client says otherwise, but its vast possibilities are quickly being realized. The great advantage of such aerial survey is that an inventory of mineral wealth can be made over an enormous area in a relatively short time, and with the basic magnetic intensity maps before him the client knows exactly where to start with his ground prospecting.

The scene is an area of country between Egersund and Sokndal in southwest Norway. The terrain is cut up with fjords and gulleys; a difficult area for aeromagnetometer work because magnetic anomalies weaken as the square of the distance from the ore deposits which cause them. In order to record a true measurement, the aircraft aims at maintaining a constant height above the ground, and what with low cloud and turbulence, the sharp changes in topography made height-keeping extremely tricky.

The area was covered on a line spacing of 500 meters at a constant above ground height of 500 feet. (This means that the aircraft, flying up and down the area to be surveyed with magnetometer switched on, covered the country in parallel lines.) Certain areas were also covered with a line spacing of 250 meters at a height of 300 feet. The necessity of the mosaic maps becomes apparent when flying along a series of parallel lines so closely spaced.

When the flying, which took three weeks, was completed the aeromagnetic records and data were sent back to England for plotting and final production of total magnetic intensity maps.

After conclusions are reached on study of the aeromagnetic maps, a program for a ground magnetometer survey is drawn up to cover apparently promising areas. The results of this survey correspond very closely to the airborne magnetometer measurements.

Titania then took the final step in the prospecting sequence to prove the existence of new ilmenite ore bodies, that of drilling, and on the site of the very first aeromagnetic anomaly discovered more than 100-million tons of good quality ilmenite.

It would have taken many years to prepare such a detailed inventory of potential deposits with former ground methods.

European Technological Developments Report Service

American companies now can keep abreast of European technological developments at less than the cost of one good researcher. This unique service is being offered by Armour Research Foundation of Illinois Institute of Technology, Chicago Ill., to a group of 16 noncompeting firms.

Under the program, the Foundation will set up a European office to funnel ideas and techniques of potential value in the American market to the participating companies.

Announcement of the program—known as the European Technical Observation Group plan—was made by Dr. H. A. Leedy, director of the Foundation.

The program is designed to meet the increasing need for up-to-date information about research and development in Europe, and is expected to have special appeal to small and medium-sized companies interested in keeping informed inexpensively.

Dr. Leedy asserted that procedures for European liaison at present are costly and haphazard and that large corporations often learn of new developments through their overseas sales offices, but most small and medium-sized firms must depend on foreign periodicals, occasional correspondence, and visits from Europeans to promote ideas.

In addition to producing usable ideas the plan will provide the following advantages: (1) Literature review and translation services necessary to keep informed of scientific progress in Europe. (2) The "insurance value" of making certain that a competitor will not obtain prior knowledge of European developments. (3) Special technical commissions will be carried out at no extra cost. And (4) valuable contacts will be established in anticipation of increased foreign trade when the Great Lakes are opened to ocean going vessels.

Initially, a European office staffed by 4 engineers under joint sponsorship of 16 noncompeting companies will be established and each engineer will be assigned prime responsibility for the 4 sponsoring companies most closely representing his field of engineering.

An electrical engineer, thus, might represent companies which produce electric motors, communications equipment, electrical instruments, and electrical components. It is expected that in his travels, an electrical engineer may run across items of interest to the other sponsors and funnel them back through the other three engineers. Under this plan, a sponsoring company would obtain almost personal attention in its field and effective coverage in related fields as well.

London Host to Convention on Ferrites

The Committees of the Radio and Telecommunication and Measurement and Control Sections of The Institution of Electrical Engineers have made arrangements for a Convention on Ferrites to be held in the Institution building in London during the week beginning October 29.

The proceedings will be opened by the president and the provisional plan for the subsequent sessions is as follows:

Session	Title
1	Opening Session including Introductory Lecture
2	Theory, Preparation, and Properties of Ferrites
3	Microwave Applications
4	Square Loop Applications
5	Radio and Television Applications
6	Carrier Frequency Applications

During the Convention there is an associated exhibition in the Institution building.

The detailed program will be available and a cordial invitation is extended to members of AIEE to be present at the sessions.

For further information contact Secretary W. K. Brasher, The Institution of Electrical Engineers, Savoy Place, London, W.C. 2, England.

Educational Offerings Made by Various Institutions

Traffic Engineering: The Yale University Bureau of Highway Traffic has announced the availability of fellowships in its Traffic Engineering course covering the next academic year of study starting September 17.

The course of graduate study is devoted to the planning and operational design of new streets, highways, and terminals as well as to the regulation and control of traffic movements on existing facilities in the interests of safe, convenient, and economic transportation of persons and goods.

The fellowships are to be awarded on a competitive basis to applicants who are residents of the continental United States and are graduates of an accredited school in engineering. A number of tuition scholarships are also available.

The fellowships offer up to $2000 each. Those wishing for information and application forms should write the Director, Bureau of Highway Traffic, Yale University, Strathcona Hall, New Haven 11, Connecticut.

Co-op Plan Degrees: Starting in June 1956, Northeastern University, for the first time, will offer Master of Science degrees under the Co-operative Plan used in the undergraduate programs in the Day Colleges. The graduate degree program will be available to students studying electrical engineering.

Students will attend classes 40 weeks and will spend a similar period working in the field of electrical engineering in co-operating companies. Initially, the new program can accommodate up to 10 students in each of the 2 divisions.

Students, on completion of the academic and co-operative work requirements, may receive Master of Science degrees in either electrical engineering or communications.

Technical Writing: Twelve technical writing authorities from national business and industry will be among the special lecturers in the fourth annual Technical Writing Institute to be conducted at Rensselaer Polytechnic Institute, Troy, N. Y., from June 11–15, by a staff of eight from the Institute's faculty in language and literature.

Nearly 200 representatives of 100 large companies have attended previous annual sessions of the Technical Writers' Institute. The intensive Monday through Friday seminar of lectures and workshop testing is designed to bring expert guidance to those who supervise technical writing in business and industry, to those newly entering the technical writing field, and to those making it their life work.

Sessions on manuals, handbooks, reports, trade promotion pieces, training programs, and graphic and illustrated materials are included in the course of lectures and in practice writing counseling. A new field of inquiry this June will be in writing for the medical and pharmaceutical houses and another will be in writing for the producers of industrial films.

Professional Development Plan: Marquardt Aircraft Company has established an Individual Professional Development (IPD) program for its technical staff.

The program will offer supplemental technical training and education designed to attain the professional goal established by the individual engineer.

IPD will have a twofold appeal in that it is designed to meet more effectively the educational needs and desires of younger engineers and those who will be joining the ranks in the future and, at the same time, it will assist in developing from among the senior engineers a reserve of qualified personnel for promotion to positions of greater responsibility.

Marquardt's IPD program will be administered by the professional personnel section of the industrial relations department, with the counsel and guidance of an Advisory Committee on Professional Advancement. The committee is comprised of company engineers.

The committee's duties will include recommendations for the establishment of educational and training courses, evaluation of established courses, and consideration of fellowships and scholarships that may be desirable to establish for Marquardt engineers.

Instrument Society Conference Features

The Instrument Society of America (ISA) has announced several interesting features in connection with its 11th Annual Instrument-Automation Conference and Exhibit (International) scheduled for New York, N. Y., September 17–21.

This annual event has become recognized as the most comprehensive instrument-automation event in the world. The ISA, being the only professional Society devoted exclusively to the theory, design, manufacture, and use of all types of instrumentation and automation control equipment for industrial, commercial, education, research, and consulting organizations, is planning a well-rounded program of technical sessions, clinics and workshops for the five day period.

Continuing its policy of encouraging advancement in the instrument industry, the Society this year will inaugurate a contest for pioneering in instrumentation. The contest will have a threefold purpose—to promote new ideas and inventions, to make known the needs of users, and to bring inventors and users together for advancement of instrumentation. Details of the contest, which will be limited to products not already on the market or on the market for not more than 6 months, will be announced shortly.

With the eyes of the world focused on the development of America's first satellite reported under construction, the instrument group is planning to devote one of its technical sessions to this startling development in the guided missile field, and hopes to have a model of the missile present at the exhibit.

European Electronics Progress Discussed and Compared to U. S.'s

Comments on the current technical and business status of electronics in Europe were made recently by Dr. Lothar Rohde, an outstanding German electronics engineer. Dr. Rohde, an expert in the vhf and uhf fields, has approximately 200 electronics patents. He was in this country to attend the convention of the Institute of Radio Engineers, where he was given a fellowship award.

He is head of the firm of Rohde & Schwarz, whose four divisions develop and manufacture a large and varied line of electronic measuring instruments and communication equipment, including frequency modulation, television, and civil aircraft communications products. The electronic measuring instruments are marketed here by the Federal Telephone and Radio Company, a division of the International Telephone and Telegraph Corporation.

Dr. Rohde commented on the remarkable recovery and expansion of electronics in Europe since World War II, although practical use of electronic equipment is far behind that in the United States. Germany is third in electronics work, preceded by England and France, because no money is spent by his government for military electronics. Great progress is being made in the frequency modulation field, used because of the lack of standard broadcast channels. He spoke on the shortage of engineers in Europe and steps taken to alleviate the problem.

X-ray Generators Are Donated to 12 Hospitals and Clinics

One of the largest philanthropic contributions of equipment toward relief of human suffering from cancer became known today when the Donner Foundation, Philadelphia, Pa., announced that it would donate 12 powerful Van de Graaff X-ray generators to as many hospitals and clinics for treatment of deep-seated cancers.

The 12 machines, valued at $68,500 each—or a total of $822,000—are 2-million-

volt X-ray generators developed and manufactured by High Voltage Engineering Corporation, Cambridge, Mass. Each institution receiving the equipment will provide necessary physical facilities and operators, and will pay for installation. Recipient hospitals will provide cancer treatment with the machine on a nonprofit basis.

The goal of the program, is to make advanced therapy available to the greatest number of cancer victims regardless of their economic status; hence, the stipulation that treatment be provided at cost.

The 12 radiation machines have already been ordered. All of them should be installed and in use by the end of 1957.

Source of the Van de Graaff's tremendous power is the machine's voltage generator and acceleration tube, both housed in a pressure vessel 36 inches in diameter and 50 inches long. When the unit is operating, an electric charge is sped on a moving belt from ground to an insulated high voltage terminal. As the charge is transferred from the belt to the terminal, a large voltage differential is built up with respect to electrical ground. A heated cathode, located in the terminal, produces a stream of electrons which hurtle downward through a glass and metal acceleration tube. In dashing through the tube to ground, these particles attain extremely high speeds (175,000 miles per second—or nearly the speed of light). This beam of electrons is fired into a special gold target, producing powerful X-rays which are then channeled in a closely controlled beam onto the area to be treated.

X-rays in cancer therapy are known to bring about a destructive action on both normal and malignant tissue. Development of supervoltage X-ray machines such as the Van de Graaff makes it possible to deliver an effective dosage of X-rays to a deep-seated tumor with much less damage to the skin and other healthy tissues than that caused by standard lower-powered X-ray sources.

The Van de Graaff's radiation beam is so intense that a patient can be treated in about 1/3 the time required using the most intense radioactive cobalt-60 source now available. This allows the hospital to give more treatments per day, with less discomfort and inconvenience for patients.

This program to ease the pain, and perhaps provide a cure, for hundreds of cancer sufferers is the outgrowth of several years' consideration by the Donner Foundation. The Philadelphia philanthropic organization was founded in 1932 with bequests from the late W. H. Donner in memory of his son, J. W. Donner, who died of cancer at the age of 35. Since that time it has provided funds for a variety of charitable undertakings. This plan, however, is one of the largest programs adopted by the group.

The technique of supervoltage treatment of cancer is based on the fact that intense beams of radiation, in this case a unique type of X-ray produced by a 2-million-volt machine, have the dual power of penetrating deep within the body and killing the wildly-multiplying cells which make up cancerous growths. Thus, if enough X-radiation can be directed into a deep-seated cancer, without excessive damage to surrounding healthy tissue, a complete cure may be effected. Even when a cure cannot be achieved, supervoltage therapy extends the life and alleviates the pain and discomfort of many cancer victims.

Tentative selection of the 12 institutions to receiver the Donner machines has already been made, and final determination will be announced determined upon the needs of the various population areas and upon the interest and experience of radiological groups available in those areas. The Foundation hopes to locate the machines in centers where such equipment either is not available or is inadequate to meet the needs of the population, provided a competent radiological staff is present to operate the facility.

Beside providing 12 new radiation therapy installations, the Foundation's effort has as a secondary goal gradual reduction in the cost of supervoltage equipment so that advanced treatment techniques possible with the machines can become available more generally.

This secondary goal was important in the selection by the Foundation of the Van de Graaff X-ray generator for this program. This equipment not only offered performance characteristics and radiation output which make possible the largest number of cancer treatments per dollar of cost, but also multiple production of the machines can promise substantial reductions in cost to future purchasers of this equipment.

The Foundation's plan would enable High Voltage Engineering Corporation to undertake a major program of engineering improvement and simplification which should lead to lower commercial prices of its therapy machines in years to come.

Evaporograph Permits "Sight" in Total Darkness

A unique instrument which makes it possible to see in the dark has just been announced by Baird Associates, Inc., Cambridge, Mass., an affiliate of American Research and Development Corporation.

The device, which utilizes no electronic circuitry, is called an evaporograph (EVA), and enables one to spot a man 200 yards away or to see a house a mile distant in total darkness.

Key to development of this instrument, originally designed for use by the armed services, is a basic principle of infrared radiation. Scientists know that different materials radiate varying intensities of infrared, depending upon temperature and surface. This radiation is present at all times, and can be detected from a distance of several miles.

In operation, the evaporograph is similar to a camera. The unit collects radiation emitted from an object and focuses it as an image onto an oil film. The oil then evaporates away from point to point at rates varying with the amount of radiation received at each point. Seen in reflected light, these differences in oil film thickness appear as different colors, like oil films on water.

A detailed thermal picture of the field of view is thus obtained in color. This picture can be viewed directly or a photographic record can be made with a camera which is incorporated in the apparatus.

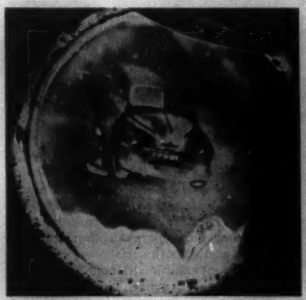
The unit is designed to observe radiation differences corresponding to temperature variations of from one to several thousand degrees F. Accurate temperature measurements can be made either visually or photographically from this evaporograph image.

EVA is housed in a cabinet 18 by 14 by 11 inches. The infrared radiation enters through a lens on one side and the operator views the oil film image through an eyepiece on the other.

The evaporograph presents a number of new areas of application in industry and research. Now it will be possible to observe simultaneously temperatures over the entire survace of a process vessel or an electronic chassis. Furthermore, it is perfectly conceivable that one could peer inside a radio tube or look at the heat of a flame, and immediately learn exact temperatures in all parts of the scene being viewed. The evaporograph also holds promise for the construction industry. A picture of a house in winter, for example, would indicate points where heat was escaping, and where insulation should be added.

Medically, the instrument is also interesting. The temperature differences over the surface of the human body are directly related to health. These differences can be seen in detail with the evaporograph, and the picture so taken has as much detail as a regular photograph.

The principle of operation of this instrument was first demonstrated in Germany by Dr. M. Czerny. Work at Baird Associates



EVAPOROGRAPH picture of parked automobile at night. Note the hot tires and radiator indicated by light spots.

PICTURE OF GIRL holding a glass of ice water taken in a completely darkened room at a distance of 30 feet. In this picture the colder spots of the objects appear as brighter spots in the image.

was originally suggested by Dr. Paul Ovrebo of the U. S. Air Force at Dayton, Ohio, and has been carried on there for the past five years. Much of the development was carried out under Signal Corps sponsorship and declassified only a short time ago.

Synthetic Fibers Exhibit at Design Engineering Show

New developments in synthetic fibers for industry will highlight the exhibit by the Textile Fibers Department of Du Pont at the Design Engineering Show, May 14–17, in Philadelphia, Pa.

Among these will be synthetic fiber paper and nonwoven fabrics, mechanically bonded reinforcing batts for plastic laminates, "Teflon" tetrafluoroethylene fiber, and many promising applications for those developments. Although a few of the new products to be shown have reached pilot or commercial production stages of development, most are experimental.

Another section of the exhibit will be devoted to commercially available industrial products of nylon, "Orlon" acrylic fiber, "Dacron" polyester fiber, and "Teflon" tetrafluoroethylene fiber. These include: rope and webbing in automobile seat belts, cargo slings, and safety belts and lines; premium industrial V-belts reinforced with "Dacron"; woven and nonwoven felt bags of "Orlon" for dust collection; fabrics of all four fibers for liquid filtration; neoprene-coated nylon tarpaulins; nonwoven felts of "Dacron"; and paper-like and nonwoven materials for electrical insulation, such as slot liners, wedges, and tapes.

Mechanically bonded reinforcing batts of nylon, "Orlon," and "Dacron" are being evaluated for a number of laminated plastic products in which the synthetic fibers can contribute chemical resistance, dielectric strength, low moisture absorption, abrasion resistance, and smooth surface.

The Du Pont exhibit will include a number of experimental products using such reinforcements as: automobile parts to which reinforcement or overlay of "Orlon" contributes smooth, uniform surface that is easy to paint and requires little finishing; meat pallets which are resistant to corrosion and stain, easy to clean, and light in weight; pipe which offers resistance to corrosion, moisture, and heat; and electrical sheeting, which serves as insulation and offers good dielectric strength and consistent performance during varying frequencies and high moisture conditions.

The exhibit of "Teflon" will include products such as: filter dust bags and liquid filter fabrics, which have given outstanding service in temperatures up to 450 F and exposure to corrosive chemicals such as concentrated sulfuric acid, hydrogen fluoride, and caustic soda; valve packings, such as used in handling hydrogen fluoride (the packing of braided "Teflon" in the exhibit valve was used without lubrication for more than 15 weeks compared with only 3 days for standard high-grade packings of conventional materials); and pump packings (the braided packing to be exhibited was used for some 30 weeks in a pump in which 5 weeks was the best previous run for standard high-grade packing of conventional materials).

Aerial Map–Electronic Computer Reduce Road Survey Time, Costs

The solving of engineering problems in highway construction through the combined use of aerial photography and electronic computation was described at an interstate meeting of highway engineers sponsored by the Federal Bureau of Roads.

Preliminary tests indicate the method can reduce surveying and engineering time 30 to 1 and costs 15 to 1, according to a joint announcement by the Computer Division of Bendix Aviation Corporation, Los Angeles, Calif., and the engineering firm of Lockwood, Kessler and Bartlett, of Syosset, N. Y.

The applications of the G-15 general-purpose computer were detailed to state road engineers of New York, New Jersey, Massachusetts, Connecticut, Rhode Island, Vermont, New Hampshire, and Maine.

The process involves these basic steps: (1) Aerial photography of proposed highway route "strips"—corrected to allow for variations in the plane's flight and tilt of camera. (2) Matching of the photographs to show the true location and elevation of every terrain feature common to them. (3) Drawing of a three-dimensional "stereopticon" contour map from which vertical, horizontal, and depth measurements can be taken along the highway route. (4) Feeding of the necessary measurement data, taken from the contour map, into the computer. The computer translates this data into precise engineering information, such as the location and size of each earth cut and fill within any specific section of the route.

At that point in the process, the section of the highway route is ready for staking and bulldozing. Earth-moving equipment can begin operations on the pattern provided by the computer's answer. A major part of field surveying—a traditional prologue to any highway construction program—thus can be eliminated by the new camera-to-computer technique.

Electronic Stethoscope Bridges Gap in Medical Diagnostics

A recently developed electronic stethoscope which is believed to be of use to the medical profession in providing an instrument to fill the gap now existing between the presently available sound-powered stethoscope and the less available and more expensive X-ray or cardiographic equipment. Its utility will provide the doctor, whose hearing is decreasing, an instrument which will fill his needs when the old sound-powered stethoscope will not suffice.

Model STE-1 Electronic Stethoscope developed by the Stavid Engineering, Inc., is the result of years of physiological design study. Sensitivity, versatility, light weight, and complete reliability have been fully realized. The development of the transistor in the electronic field—units with extrapolated life curves indicating service life in excess of 50,000 hours, with low power requirements to eliminate the high maintenance costs of vacuum tube amplifiers—make possible the realization of an electronic stethoscope satisfying high sensitivity requirements for hospital and clinical use as well as for the practioner's office.

The study preceding development of the stethoscope indicated that a method of eliminating unwanted sound would be a most useful feature. Therefore, a *hi-lo* switch to select either of two band pass filters has been incorporated; the switch is placed in the *lo* position for cardiac and pulse observation and in the *hi* position for chest and lung work. Over-all sensitivity is selected by a *hi-lo* power switch on the amplifier case. Volume adjustments can be made by the volume control on the amplifier and finer adjustment by means of the loudness control built into the lightweight head-set. These features permit adjustment of sound level to suit the individual user, providing maximum amplification of weak signals when needed.

Additional features include sterilization of the earpieces of the head-set and the detachable probes by standard sterilization methods without damage. The constituent units of the electronic stethoscope are easily stowed in the lightweight carrying case provided. All power requirements are met by two penlight 1.5-volt cells; with normal use battery life will be in excess of six months. Replacement batteries are, of course, readily available from standard supply sources.

Electronic Eyes Aid Production of Transistors

An electronic temperature-control system that literally "sees the heat" with a sapphire rod has been successfully applied to the growing of silicon crystals—the metallic heart of transistors—it was reported recently by Minneapolis-Honeywell Regulator Company, and developed by the firm's Industrial Division, Philadelphia, Pa., in co-operation with Philco Corporation's Research Laboratories. Conventional control methods call for use of temperature-sensitive thermocouples that are slower reacting and "burn out" quickly under high-temperature conditions necessary for growing silicon crystals.

Crystal growing, is generally regarded as one of the touchiest phases in transistor production. Raising, or "pulling" silicon crystals is as delicate an operation as raising hothouse orchids—both require precise temperature regulation. To produce a single crystal, the silicon is melted in a special quartz-lined carbon crucible. A rod to which is attached a small amount of crystal—the "seed"—is lowered into the molten silicon. As the rod is slowly withdrawn from the crucible, the melt forms a single crystal about the seed. The speed with which it is pulled and the temperature of the molten silicon determine the size and quality of the crystal. For example, improper temperature control can result in crystals with odd formations, making them unusable.

In the new control system, the sapphire rod (a single, pure crystal of aluminum oxide, 1/8 inch in diameter and generally about 12 inches long) acts as a transmission line for the infrared rays. The rod is focused on the bottom of the crucible holding the molten silicon and transmits radiant energy back through the rod to a thermopile (a special temperature-sensitive unit) which relays the findings to the control system proper. This then adjusts the furnace temperature by regulating the power feed.

The radiation control system is said to eliminate the measuring lag characteristic of thermocouple systems. It also provides an average measurement of the molten silicon temperature as contrasted to measurement of a single point. The sapphire rod is especially suited for accurate measurements at temperatures around 1,500 C, and has an appreciably longer life than the thermocouple-type sensing units.

The control system is being utilized in pilot production operations of silicon crystals in transistor manufacturing operation at Philco's Lansdale tube and transistor plant.

The sapphire rod pyrometer control system also is being successfully applied to the production of germanium crystals, from which other transistors are manufactured.

Television Equipment Designed for Small Communities

New low-power television broadcasting "packages" designed to meet the needs of an estimated 800 small communities where television has been unavailable because of the high cost of conventional equipment has been announced by Philco Corporation, pointing out the equipment's importance to national security. Thus, a truly nation-wide television system is possible, and its importance during natural, or enemy caused, disasters cannot be underestimated.

Low-power television offers to small community enterprises an inexpensive advertising potential. The value of low-power television equipment has been proved by the armed forces which has used it for information and educational stations, and for battlefield surveillance.

The final power amplifier provides 150-watt peak visual power and 75-watt aural power output to the transmission line. The program originating equipment consists of film and live camera chains, video monitoring and switching facilities, and audio facilities. The frequency band used in battlefield surveillance—470 to 500 mc—can be covered by the transmission equipment.

Because most low-power television stations will want to pick up network programs from large, nearby cities, high-quality microwave relay equipment is being offered with the "package." Equipment can be used for monochrome and color television.

The Federal Communications Commission (FCC), in establishing its nation-wide plan of television broadcast sought to provide at least one channel assignment each to the maximum number of communities. However, 890 communities of 1,241 having channel assignments failed to establish stations because of high initial cost and maintenance. On the recommendation of RETMA (Radio-Electronics-Television Manufacturers Association), the FCC amended its rules last year permitting use of low-power equipment. Philco is the first large manufacturer to produce low-cost, low-power television equipment for small communities.

This equipment consists of a driver—a crystal control modulator unit which produces modulated visual and aural television program carriers; an intermediate amplifier of 20 watts power—a multistage linear amplifier using *2C39A* triodes—and a final power amplifier which uses a single *6283* tetrode. Both omnidirectional antennas and high-gain directional antennas are included in the line. The particular antenna to be specified in an application depends upon the location of the transmitter in relation to the community.

Package *A* consists of equipment to handle film and network programs; Package *B* will handle film, network and live (single camera); and Package *C* will handle film, network and live (two studio cameras).

Irradiated Synthetic Has Greater Tolerance for Heat

Exposing a specially formulated plastic to a beam of electrons—moving at almost the speed of light—has produced a new electrical insulation with greater tolerance for heat.

Specially formulated polyethylene is being marketed under the trade name "Hyrad" by Sequoia Process Corporation, whose Redwood City main plant is already in quantity production.

Results of the work by Sequoia and Stanford Research Institute, Menlo Park, Calif., represent a major development in the relatively new field of radiation chemistry and in the technology of electrical insulation with polyethylene.

Radiation study entailed exposure to radiation by SRI's cobalt-60 source of gamma rays of some specially prepared wire samples insulated with modified polyethylene.

Unlike some commercial plastics which are degraded by radiation, Hyrad is improved by the process and especially adaptable as a jacketing material for wire and cable in such high-temperature environments as jet aircraft and various electronic components.

Another feature is Hyrad's elastic "memory," which enables a tight shrink-fitting under considerable tension for insulating capacitors, lugs, splices, and soldered joints.

Source of the process radiation is a General Electric Electron Beam generator housed at the Redwood City plant.

Electrical Equipment Seen Revolutioned by Aluminum Wiring

Technological development of lightweight anodized aluminum wire was disclosed by Aluminium Limited Sales, Inc., United States distributing subsidiary of Aluminium Limited, Montreal, Que., Canada.

Metallurgists of the company have developed, after years of research, a process of anodizing aluminum wire with alternating current to give it a ductile oxide coating which, in effect, becomes an electrical insulation.

New horizons in design are open to electrical equipment manufacturers as a result of this development.

Electrical equipment wound with light, heat-resistant aluminum wire, instead of the heavier copper wire now used universally, could be made smaller, cheaper, and lighter, and could be run hotter.

Aluminium said that solutions to the few remaining technical problems in the wide use of anodized wire are being sought in co-operation with electrical equipment manufacturers in the United States.

Developed in Canada by the Aluminum Company of Canada (ALCAN), principal subsidiary of Aluminium Limited, the process involves pulling the aluminum wire through tanks containing chemical solutions which quickly give it a hard, thin coating.

In 18 months of research at a plant at Shawinigan Falls, Que., Canada, ALCAN metallurgists overcame two major obstacles: (1) a process capable of providing an insulated film at commercial speeds was devised, and (2) an anodic film sufficiently ductile to withstand the stressing and flexing operations involved in winding electrical coils was developed.

The lack of these properties has prevented the use of anodized aluminum wire for this purpose in the past.

The possibility of using anodic films as an electrical insulant for aluminum has intrigued engineers for the last 25 or 30 years. Aluminum oxide, which is built up by anodizing, is an insulator that maintains its insulating properties at extremely high temperatures. The normal insulating materials used on magnet wires for winding electrical machines are organic. Therefore, they lose their insulating properties rapidly if temperatures rise above 80 or 100 C.

Engineers have long felt that if an insulant with higher temperature characteristics could be obtained, substantial economies in the use of component parts would be possible and great reductions in weight and size realized. Aluminum has offered this potential, but until now the anodically produced films have been too brittle and the cost of producing films with electrical properties has been too great for commercial use.

Billionth-of-a-Second "Stop Watch" Developed

Split-second timing has been given a new degree of meaning by scientists at the Westinghouse Research Laboratories.

The world's fastest "stop watch"—an electronic tube which can time atomic "events" down to less than one billionth of a second—has been developed.

Actually, the Westinghouse scientists report, the exact top speed of their new "stop watch" must await development of better laboratory techniques to measure it experimentally. But the tube has been timed down to the billionth of a second figure, and calculations show it is probably 10 times faster than this.

A photomultiplier tube strengthens weak pulses of radiation and detects the time intervals between them. An important application of the new Westinghouse tube will be for fundamental research in nuclear physics, where it will be used to time with great extactness the flight of speeding atomic particles.

An electron, released by a pulse of radiation entering the tube, strikes the front surface of an exceedingly thin nonmetallic film and "knocks" several additional "bonus" electrons from its back surface.

An electric fields speeds up new electrons and "aims" them at a second film, where each one releases more electrons from that

film. This increase of electrons continues through several steps, or "stages." The result is that several million electrons are obtained for each one released in the beginning. In this way the tube gets its multiplying effect.

Conventional photomultiplier tubes use thick metal plates instead of thin films to obtain the "bonus" electrons. In such tubes the electrons must be "guided" through a number of complicated paths in going through the tube.

It will permit measuring, with a new order of precision, the speed and, therefore, the energy of atomic particles as they "smash" into atoms and produce nuclear reactions, or as they are ejected from the atom during such reactions. This new order of precision, it is believed, will give new insight into the causes and effects of nuclear reactions and, perhaps, into the structure of the atomic nucleus itself.

The thin film which supplies the "bonus" electrons is an extremely thin layer of a material similar chemically to common table salt. Only two-millionths of an inch thick, the salt film is evaporated in a vacuum onto a five-times-thinner film of a glasslike material which helps give strength to the salt film. Between these two films is deposited a third film of gold, more than 200 times thinner than the salt film itself.

This three-layer "sandwich" is mounted on the surface of a round copper screen, its mesh so fine that the holes in the screen cannot be distinguished with the naked eye. So thin is the entire "sandwich" on the face of the screen, that it would require 1,000 of them stacked one on top of another to equal the thickness of an average sheet of writing paper.

The successful construction and operation of this new photomultiplier tube was made possible only because of recent research techniques for producing metallic and nonmetallic films in unprecedented thinness.

Special Courses at Pennsylvania State University

A seminar primarily for engineers responsible for the operations of electrostatic precipitation equipment will be held at The Pennsylvania State University, University Park, Pa., June 11–15.

During the first one and one-half days, the principles underlying the electrostatic precipitation process will be discussed.

The remainder of the seminar will be concerned with several areas of electrostatic precipitator applications: i.e., public utilities, the steel industry, air cleaning for air conditioning and other uses.

Small discussion groups will be arranged around specific problems in electrostatic precipitation, with one or more qualified resource persons sitting with each group. The week-long meetings will be sponsored by the University's College of Engineering and Architecture and General Extension services.

Another seminar on the fundamentals and applications of electrical contacts will be held for scientists and those experienced in this field at the university, June 25–29.

During the first two days a review on the physical principles of electrical contacts will be made.

Electrical contact applications will be stressed during the balance of the seminar. In addition, scientists and engineers, involved either in the manufacturer or in the use of contacts, will present individual papers.

Another feature of the seminar will be the small group discussions on specific electrical contact problems, with one or more resource men sitting with the group.

This seminar also is sponsored by the College of Engineering and Architecture at the university and General Extension services.

A technical writing workshop to provide practical instruction and supervised practice in the efficient preparation of effective technical reports will be held at The Pennsylvania State University, September 16–28.

To make individual instruction possible, the workshop will be limited to 40 practicing scientists and engineers. The two-week sessions will consist of morning lectures and afternoon workshop periods, covering all aspects of good technical writing and methods of achieving them.

In addition, two evening lectures will be delivered by experts in highly specialized fields of technical communication.

Each registrant will be asked to bring an actual writing project with him to make the workshop sessions as meaningful as possible.

Fissionable Materials Standards Are Being Instituted

Public safety groups, Government agencies, and 17 industries making use of atomic energy have begun work on national standards for the commercial and industrial use of fissionable material.

The group of 36 individuals, making up a Planning Committee for Standards in the Field of Nuclear Energy, met in February 1956 in New York, N. Y., to further discussions begun in December 1955 to establish standards according to procedures of the American Standards Association.

The Planning Committee, under the chairmanship of Morehead Patterson, president and chairman of the board, American Machine and Foundry Company, appointed committees to plan work in six major areas: general or administrative standards such as those for terminology, symbols and color codes; radiation protection of people and property; standards for nuclear safety, such as site location, laboratory experimentation, and transportation or storage; standards for equipment; and for processes and for materials.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Weight of a Kilowatt-Hour

To the Editor:

I am interested in the computation of B. J. George in "Letters to the Editor" in *Electrical Engineering* of March 1956. Since energy can be stored as an electric field between capacitor plates I think that it would be more appropriate to consider it as "non-material" and depend only on Einstein's equation. My store of useless information comes up with the following:

1 kwhr = 3,600,000 joules

$= mC^2$ where m is in Kg and C is the velocity of light in m per second

$$\text{Thus, } m \text{ (in lbs)} = \frac{(3{,}600{,}000)(2.2)}{(3\times10^8)^2}$$

$$= 0.88 \times 10^{-10} \text{ pound}$$

At an assumed rate of 3¢ per kwhr this results in

$$\text{Cost} = \frac{0.03}{0.88\times10^{-10}} = \$341{,}000{,}000 \text{ per pound}$$

Yours,

L. A. WARE (AM '36, M '43)

(State University of Iowa, Department of Electrical Engineering)

To the Editor:

In the March issue (1956) of *Electrical Engineering* under "Electrical Oddities" of the Letters to the Editor section, Mr. B. J. George expressed a relationship between a kwhr of electrical energy and its equivalent weight. It appears in my judgment that the inherent mass energy of an electron and the electrical energy imparted to an electron as generated in a potential difference device (dynamo or battery) are not equivalent.

General theory states that energy received by an electric charge in a continuous electrical circuit from a potential source is equal to the energy it expends through the circuit. Or, an electric charge does work in traversing a circuit by evolution of heat and operation of electromechanical devices equal to the work performed on it. Thus, it is the vehicle for transfer of electrical energy and not the source of it.

$$P = EI = \frac{W}{q}\times\frac{q}{t} = \frac{\text{work}}{\text{unit charge}}\times\frac{\text{unit charge}}{\text{unit time}}$$

$$P = \frac{W}{T} = \frac{\text{work}}{\text{unit time}}$$

and,

$$\text{Work} = \text{Energy} = Pt$$

The energy contained in an electron is inherent to its kinetic energy of motion and its mass. An atomic reaction is necessary to release this energy. Now the equivalence

of mass and energy is expressed in Einstein's equation, $E=mc^2$. By plugging proper values into this equation, my calculations result in a value of equivalence between a kwhr and mass of 0.4×10^{-7} gm ($9+10^{-11}$ pound) from,

$$M=\frac{E}{C^2}=\frac{10^8\times3.6\times10^3}{(3\times10^{10})^2}$$

where velocity of light $C=3\times10^{10}$ cm per second

1 wattsecond $=10^7$ dyne-cm $=1$ joule

As a comparison in end results, 4×10^{-7} pound calculates out to be about 4×10^3 kwhr. In any case, if we are to market energy on the "Weight" basis, I should strongly urge use of metric units since they multiply and divide out so simply, and many thanks to Mr. George for an interesting diversion.

Yours truly,

H. J. ANTOSZ (AM '47)

(Bureau of Yards and Docks, Navy Department)

To the Editor:

It seems to me that Mr. B. J. George underestimated the value of our product in his letter published in the March issue of *Electrical Engineering*, in which he values electrical energy at $200 million per ton. I believe his calculation procedure is incorrect because it involves an arbitrary assumption of a voltage level, and also because he calculates the weight of electrons required to transmit a given amount of energy rather than the weight of the energy itself.

Actually we know from the work of Einstein and others that mass and energy can be considered as merely two aspects of the same thing. For example, the size of either a photon or an electron can be expressed in terms of either mass units or energy units. A change in the velocity of an electron manifests itself both as a change in mass and as a change in kinetic energy. The equation expressing this mass-energy equivalence, which can be thought of as expressing a relation between two systems of units, is of course the well-known relation $E=mc^2$.

With this equation it can be found that one kilogram (2.2 pound) of mass is 25 billion kilowatt-hours of energy. Hence, if electrical energy is worth 4¢ per kilowatt-hour, it is worth approximately $900 billion per ton.

Very truly yours,

P. ROGER GILLETTE (AM '52)

(Stanford Research Institute)

To the Editor:

I have read with much interest the letter from Mr. B. J. George upon the weight of 1 kwhr. I believe he has confused the *mass* of an electron with its *weight*. His quotations on *mass* are correct but he has employed them as *weight*. With O=16 atomic weight, the Smithsonian tables present the *weight* of an electron: atomic weight $=(5.479\pm0.003)10^{-4}$ gram. Hence, 1 gram-mol of electrons weighs $(5.479\pm0.003)10^{-4}$ grams. If, I be incorrect forget it. If, I am correct rewrite Mr. George's very interesting letter accordingly, please.

The easiest way to state the problem is that 1 gram of any *known* matter is equivalent to 25×10^4 kwhr. This does not include the matter of the white dwarf stars whose densities go from a specific gravity of 2,000 up, about which we know nothing.

Yours very truly,

CLARENCE E. ROSE (AM '49)

(Yellowstone District, U. S. Bureau of Reclamation)

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

SOLID-STATE PHYSICS. Volume I: Advances in Research and Applications. Edited by Frederick Seitz and David Turnbull. Academic Press, Inc., 125 East 23rd Street, New York 10, N. Y., 1955. 469 pages, 9¼ by 6 inches, bound. $10. The first volume in a projected series of 12 volumes intended to fill the need for compact and authoritative reviews of important areas of the field. Contained in this volume are six papers devoted to the following subjects: methods of the one-electron theory of solids; qualitative analysis of the cohesion in metals; the quantum defect method; the theory of order-disorder transitions in alloys; valence semiconductors, germanium and silicon; and electron interaction in metals. Bibliographical footnotes accompany each paper, and a subject index and index of authors cited are included.

DIE PRÜFUNG ELEKTRISCHER MASCHINEN. By Werner Nürnberg. Springer-Verlag, Berlin, Germany, 3d edition, 1955. 414 pages, 9¼ by 6⅓ inches, bound. DM 29.40. Intended both for students and practicing engineers, this volume on the testing of electrical machines covers general procedures, test equipment and methods, and separate sections dealing with major types such as transformers, synchronous machines, asynchronous machines, d-c machines, etc. A special section deals with metadyne and amplidyne rotating regulators.

MODERN OSCILLOSCOPES AND THEIR USES. By J. H. Ruiter, Jr., Reinhart and Company, Inc., 232 Madison Avenue, New York 16, N. Y., revised edition, 1955. 346 pages, 9¼ by 6 inches, bound. $6.50. A practical book on the principles, components, and uses of the oscilloscope, with detailed information on each element and step-by-step explanations of procedures for its use in many fields. A brief history of the oscilloscope, a review of fundamentals of the cathode-ray tube, and a discussion of circuits of the oscilloscope are included. In this edition, textual changes have been made to bring the material up to date, and a new chapter has been added covering circuits for quantitative measurements.

MASS-TRANSFER OPERATIONS. By R. E. Treybal. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1955. 666 pages, 9¼ by 6¾ inches, bound. $9.50. The first part of this 5-part book is a discussion of basic considerations of diffusion rates: molecular diffusion in fluids, diffusion in turbulent flow, diffusion in solids, and interphase mass-transfer. These basic considerations are applied in the succeeding three parts to gas-liquid, liquid-liquid, and solid-fluid operations, and the final part deals with contact of miscible phases. In treating the various unit operations; dehumidification, gas absorption, ion exchange, etc., both theoretical material and principles of the design and operation of equipment are presented.

AN INTRODUCTION TO REACTOR PHYSICS. By D. J. Littler and J. F. Raffle. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1955. 196 pages, 8¼ by 5⅓ inches, bound. $4.50. A detailed presentation of the calculations used in evaluating the critical size of a gas-cooled, graphite moderated, natural uranium reactor of the type intended for use in the nuclear energy power program of the United Kingdom. The book also includes an account of the nuclear physics essential for an understanding of the construction principles and sufficient theory for an understanding of the problems involved in the construction of other types of reactors. Separate chapters are devoted to shielding, instruments, and radiation damage to structural materials.

HALBLEITERPROBLEME. Edited by Walter Schottky. Friedrich Vieweg and Sohn, Braunschweig, 1954. 387 pages, 222 pages, 9⅓ by 6¼ inches, bound. DM 28.80 each. These two volumes contain 28 specialised articles on various aspects of semiconductor properties and effects, including discussions of polar crystals; electron interactions and transitions, electrolytic rectifiers, selenium and copper oxide rectifiers, transistor characteristics, photoconductivity, and metal electrodes with nonmetallic surface layers. The articles are mainly in German, with English summaries.

ATOMIC PHYSICS. By G. P. Harnwell and W. E. Stephens. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1955. 401 pages, 9¼ by 6¼ inches, bound. $8. Using as a point of departure the aspects of classical physics essential to the concepts on which atomic theory is based, this book presents the fundamental physical ideas relating to the nature of matter and radiation, atomic structure, electron spin, polyelectronic atoms, and molecular structure. Two chapters are devoted to the statistical description of elementary particles and to those properties of solids, liquids, and gases capable of being dealt with by the current theory on an elementary mathematical level.

BLITZSCHUTZ. Edited by Ausschuss für Blitzableiterbau. Wilhelm Ernst and Sohn, Berlin, Germany, 6th edition, 1955. 99 pages, 8⅓ by 6 inches, bound. DM. 7.90. This small book presents a general survey of present-day knowledge concerning the origin and effects of lightning, and discusses the important factors to be considered in the construction of lightning protectors. Sketches are included showing installations for a variety of common building types.

VACUUM VALVES IN PULSE TECHNIQUE. By P. A. Neeteson. Philips' Technical Library, Eindhoven (available in the United States from Elsevier Press, Houston, Tex.) 1955. 170 pages, 9 by 6 inches, bound. $4.50. This is a presentation of methods for the analysis of circuits using vacuum tubes as switches. It includes a thorough treatment of the grid circuit and anode circuit, both for the triode and pentode; a fairly extended discussion of multivibrators; and brief chapters covering basic theory and relevant principles of operational calculus.

A TEXTBOOK OF SOUND. By A. B. Wood. Third edition, The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y., 1955. 610 pages, 5¼ by 9⅓ inches, bound. $6.75. Dealing with vibrations of all frequencies, audible or otherwise, this book covers theory; vibrating systems and sources of sound; and sound transmission, reception, transformation, and measurement. It also includes a section on applications, including measurement of distance, acoustics of buildings, recording and reproduction, and musical instruments. The treatment is on the level of the engineering student, with footnote references to original papers provided for those interested in more detailed information.

TEMPERATURE—Its Measurement and Control in Science and Industry. Volume II. Edited by H. C. Wolfe for the American Institute of Physics. Reinhold Publishing Corporation, 430 Park Avenue, New York 22, N. Y., 1955. 467 pages, 6¼ by 9¼ inches, bound. $12. The emphasis in the 24 papers contained in this volume is on the basic physics involved in temperature concepts and measurements. Included are discussions of temperature in very hot gases and in matter near absolute zero, standards and scales in use at present, the use of semiconductors and superconductors for measurement, and sound velocity as a measurement of gas temperature. Engineering aspects of the subject deal with standard and specialized methods of measurement, and with temperature measurement in steel making.

SPECTROCHEMICAL ABSTRACTS. Volume IV: 1946–1951. By E. H. S. van Someren and F. Lachman. Hilger and Watts, Ltd., London, N. W. 1, England. 1955. 179 pages, 9¼ by 6 inches, paper. $5.75. A compilation of about 800 references dealing with emission spectroscopy in its analytical applications. The publication contains an author listing, an abstracts section arranged by subject, and an index to elements in samples. Reviews, tables, atlases, and books are listed separately.

ASTM STANDARDS ON PLASTICS. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1955. 790 pages, 9 by 6 inches, paper.

$5.75. This is a new edition of a special compilation of all the specifications, methods of test, definitions, etc., relating to plastics. Of the 143 standards included, 4 are new and 41 have been revised, reaffirmed, or advanced from tentative status since publication of the previous edition in 1954.

COLOR TELEVISION ENGINEERING. By J. W. Wentworth. McGraw-Hill Book Company, Inc., 330 West 42 Street, New York 36, N. Y., 1955. 459 pages, 9½ by 6¼ inches, bound. $8. Written as an introduction to the field for engineers with a knowledge of monochrome television, this book covers principles of color, including color perception and measurement; color reproduction; transmission systems; and apparatus and circuits. In the section devoted to transmission, nearly all proposed multiplexing techniques are discussed. Equipment both for compatible broadcasting and closed-circuit applications is treated.

THE COOLING OF ELECTRIC MACHINES AND CABLES. By Theodore de Koning. Zuid-Nederlandsche Drukkerij, 's-Hertogenbosch, Holland, 1955. 233 pages, 9¼ by 6 inches, bound. Blue cover for libraries and individuals $5, red cover for electrical manufacturers $15. This book contains eight papers illustrating the author's thesis that making cooling a basic design principle would lead to major improvements in electrical machinery and cables. Four of the papers deal with large machines, one with a-c motors of the series and production range, and one with the cooling of paper-insulated high-voltage cables. The remaining papers are concerned with skin cooled electric ship propulsion motors and electric drivers for rolling mills.

LES DISLOCATIONS ET LA CROISSANCE DES CRISTAUX. By W. Dekeyser and S. Amelinckx. Masson et Cie., Paris. 1955. 184 pages, 7 by 9¼ inches, paper. F frs. 2,000. An analytical treatment of the theory of the spiral growth of crystals and of the influence of dislocations. Topics covered include the movement of dislocations, crystal growth theories, measurement methods, classification systems, growth spirals and their interaction, and corrosion formations. Sketches and diagrams illustrate the text, and a group of photomicrographs is appended.

ELECTRONIC ENGINEERING. By Samuel Seely. McGraw-Hill Book Company, Inc., 330 West 42 Street, New York 36, N. Y., 1956. 525 pages, 6¼ by 9¼ inches, bound. $8. This volume, along with its companion volume "Radio Electronics," now in press, is a revision and extension of the author's "Electron-tube Circuits". The book is devoted mainly to the physical explanation and mathematical analysis of circuits in the fields of radar, television, control, instrumentation, and computers, and deals with such representative devices as untuned potential amplifiers, oscillators, sawtooth and other sweep generators, and rectifiers. Chapters on solid-state theory and transistors as circuit elements are also included.

ENGINEERING DRAWING AND GEOMETRY. By R. P. Hoelscher and C. H. Springer. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1956. Various pagings. 8¾ by 11¼ inches, bound. $8. This text, designed specifically for engineering students, emphasizes thoroughness in the understanding of principles rather than the achievement of manual skill. All the theory in descriptive geometry necessary for solving problems in design and drafting has been concisely presented. Drawing has been approached from the point of view of engineering usage as a whole. The treatment of dimensioning, for example, covers practices which apply in all fields; and map, structural, pipe, tool, machine, and welding drawing are covered.

FUNDAMENTALS OF ELECTROACOUSTICS. By F. A. Fischer. Translated by Stanley Ehrlich and Fritz Pordes. Interscience Publishers, Inc., 250 Fifth Avenue, New York 1, N. Y., 1955. 186 pages, 8¾ by 5½ inches, bound. $6. An introduction to the subject for engineers and physicists, translated from the German version published in 1950. Approaching the subject from the electrical engineering standpoint, the author deals first with electric and mechanical oscillators, then forces. Succeeding chapters deal with energy conversion principles, electroacoustic transducers, the radiation of sound, the efficiency of a sound source, the sensitivity of transducers, and broad band transducers. Concluding chapters discuss electromechanical coupling and transducers employing electric resistances.

INTRODUCTION TO TV SERVICING. By H. L. S. Swaluw and J. Van Der Woerd. Philips Technical Library, Eindhoven (available in the United States from Elsevier Press, Houston, Texas). 1955. 264 pages, 8¼ by 6 inches, bound. $5.50. Although primarily intended for radio technicians preparing for television servicing, this book may be of interest to engineers in other fields who wish a concise and clear presentation of some of the fundamentals of receivers and of methods for making simple repairs. In addition to giving practical information on instruments, locating defects, and the repair of defective components, the book includes an explanation of the working of the picture tube and scanning system, a detailed description of a modern receiver, and chapters on intercarrier sound and the turret tuner.

LOW TEMPERATURE PHYSICS. By L. C. Jackson. Fourth edition, John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1955. 158 pages, 4¾ by 6¾ inches, bound. $2. A concise survey of the general principles of selected aspects including the production and measurement of low temperatures, liquid and solid helium, specific heats, electrical conductivity, and magnetism. A brief bibliography is supplied for those interested in more comprehensive studies of the subjects discussed.

MODERN PHYSICS—A Textbook for Engineers. By Robert L. Sproull. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1956. 491 pages, 6 by 9¼ inches, bound. $7.75. An analytical introduction to physics and its applications, based on a course given to undergraduate students and engineers in industry. The opening chapters cover particles and their interactions, and the laws that govern the behavior of particles in atoms and nuclei. Quantum mechanics, introduced early in the book, is used throughout to provide explanations of such engineering problems as the operation of transistors, characteristics of electron tubes, and nuclear reactors. Whenever possible the experiments of modern physics are applied to engineering instrumentation and to the understanding of processes and materials.

NUCLEAR MAGNETIC RESONANCE. By E. R. Andrew. Cambridge University Press, 32 East 57th Street, New York 22, N. Y., 1955. 265 pages, 8¼ by 5¼ inches, bound. $6.50. A comprehensive review covering basic theory, experimental methods, applications in the measurement of nuclear properties, and the properties and applications of the phenomenon in liquids and gases, nonmetallic solids, and metals. Some of the many applications discussed are the use of the resonance spectrum to reveal information on the structure of nonmetallic solids, to study the magnetic properties of ferromagnetic crystals, to provide information on the short-range order of alloys, and to discover defects in both metals and nonmetallic solids. A bibliography of over 400 references is included.

NUCLEAR RADIATION DETECTORS. By J. Sharpe. John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1955. 184 pages, 6¾ by 4¼ inches, bound. $2.50. A brief summary of basic information intended for users and designers of detectors. The discussion covers the processes by which neutrons and electromagnetic radiation produce effective particles; the interaction of nuclear radiation with matter; detection media; the efficiency of detectors; scintillation counters; and ionization devices. References are listed after each chapter, and a general bibliography is appended.

OVERHEAD LINE PRACTICE. By John McCombe. Second edition, Macdonald and Company (Publishers) Ltd., London, 1955. 287 pages, 5¾ by 8¾ inches, bound. 25s. A clear presentation for engineers, foremen, linesmen, and others, of the details of the layout, design, and erection of overhead power lines. All the aspects of the work, from surveying to inspection and testing of lines are covered. In this edition there are new sections on sag-tension calculations, aluminum alloy conductors, and maintenance; the chapter on legal notices and right-of-way has been omitted.

PREVENTIVE MAINTENANCE OF ELECTRICAL EQUIPMENT. By C. I. Hubert. McGraw-Hill Book Company, Inc., 330 West 42 Street, New York 36, N. Y., 1955. 214 pages, 6¼ by 9¼ inches, bound. $4. A reference manual for engineers and maintenance electricians, as well as a supplementary text for engineering students. The book describes practical programs for the maintenance of motors, generators, batteries, electronic equipment, etc. It also treats trouble-shooting methods, with emphasis on emergency repairs, and presents correct operating procedures as essentials of a workable maintenance program. An annotated list of films and filmstrips on various phases of the subject is given in an appendix.

PROFESSIONAL ENGINEER'S EXAMINATIONS—QUESTIONS AND ANSWERS. By W. S. LaLonde, Jr., McGraw-Hill Book Company, Inc., 330 West 42 Street, New York 36, N. Y., 1956. 462 pages, 5½ by 8¼ inches, bound. $6.50. Of the 500 problems in this book 80 per cent have been taken from past examinations given in many states; the remainder have been added to give better coverage of some subjects. The questions have been selected to represent all the major phases of examinations for professional engineers and engineers in training, and the answers are given in the detailed form acceptable to examiners. General information on registration, experience qualifications, etc., is included in an introductory section.

REGELUNGSTECHNIK. By Georg Hutarew. Springer-Verlag, Berlin, 1955. 176 pages, 6¼ by 9¼ inches, bound. DM 21. An introductory text in the field of mechanical control methods, including a detailed treatment of the regulation of hydraulic turbines. The treatment is sufficiently mathematical to cover the theory for the student as well as providing a practical approach for the engineer.

ROTOR CRAFT. By R. N. Liptrot and J. D. Woods. Butterworths Scientific Publications, London, 1955. 161 pages, 10 by 6½ inches, bound. $5. A simple and practical explanation of the fundamentals of rotary wing aircraft engineering, designed as a guide to the engineer in his daily work. Fairly extensive chapters are devoted to rotor aerodynamics, the articulated rotor, and control and stability; brief chapters to the description and operation of the helicopter, vibration and noise, design study procedure, and the economics of the helicopter. A fully illustrated historical summary, a glossary, a list of specifications, a directory of manufacturers, and a bibliography are also included.

SPECIFICATIONS AND TESTS FOR ELECTRO-DEPOSITED METALLIC COATINGS. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1955. 96 pages, 9 by 6 inches, paper. $1.85 (ASTM members $1.40). The specifications included deal with coatings of zinc, cadmium, nickel-chromium, and lead on steel; nickel-chromium on copper and zinc; and chromate finishes on zinc coatings. Local thickness and other test methods are included, as are several recommended practices for chromium plating on steels and the preparation of various metals for plating.

VDE FACHBERICHTE UND ÜBERSICHTS-VORTRÄGE. Volume 18, 1954. 1955, Verband Deutscher Elektrotechniker, VDE Verlag, Wuppertal-Elberfeld. Various pagings, 8¾ by 11¾ inches, paper. DM 19. The 38 reports published in this volume are intended to provide a broad picture of recent research and development in the field of electrical engineering. The reports are broadly classified under the following headings: materials; electronics; measuring techniques; power production and tranmission; electric machinery; control and regulation; converters; communications; power engineering and allied fields.

ALTERNATING-CURRENT CIRCUIT THEORY. By M. B. Reed. Harper and Brothers, 49 East 33rd Street, New York 16, N. Y., second edition, 1956. 589 pages, 6¼ by 9½ inches, bound. $6.50. This volume contains both fundamentals and applications. Experimental evidence for a theory is followed by a complete mathematical development. Particular attention is paid to the establishment of a working knowledge of reference directions and polarities of currents and voltages. Many illustrative examples are given, and a group of problems accompanies each chapter.

ELECTRIC GENERATION: STEAM STATIONS. Edited by B. G. A. Skrotzki. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1956. 454 pages, 6¼ by 9¼ inches bound. $8.50. A treatment in simple terms of the basic principles of design, operation, and maintenance. Practical information on fuels, fuel and ash handling, steam generators, and fuel-burning equipment is included, and piping systems, turbines, condensers, and water treatment are covered in detail. Instruments and control, electric generators, station circuits, auxiliary drives, and super-pressure stations are also discussed. The mathematics used is limited to arithmetic and simple algebra.

ELECTRIC NETWORK SYNTHESIS. Image Parameter Method. By M. B. Reed. Prentice-Hall, Inc., Englewood Cliffs, N. J., 1955. 252 pages, 6¼ by 9¼ inches, bound. $8. The image parameter method of filter design is presented in this book in terms of image impedance and image transfer functions. General properties of two and four terminal networks, low-pass structures, low-pass lattices, ladder networks, and other

aspects of the subject are dealt with separately, then considered together in a discussion of the design of a specific low-pass filter. One chapter shows how low-pass techniques can be used in the design of high-pass, symmetrical band-pass, and symmetrical band-block filters, and a chapter on the design of equalizers is also included.

ELECTRICAL ESTIMATING. By Ray Ashley. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., second edition, 1956. 363 pages, 7⅞ by 10½ inches, bound. $8. For the engineer and contractor who must solve complex problems of estimating, appraisal, cost accounting, job scheduling, or supervision in the electrical construction field. It sets forth the essential methods and practices of professional electrical estimating and provides in sample estimates and guides, a basis for training new estimators. This new edition contains full discussion of labor units with tables for practice estimating. A detailed question and answer section has been appended.

ELECTROMAGNETIC WAVES. By G. T. di Francia. Interscience Publishers, Inc., 250 Fifth Avenue, New York 1, N. Y., 1955. 320 pages, 6 by 9¼ inches, bound. $6. The purpose of this book is to present a clear and readily understandable introduction to the theory and applications of electromagnetic waves. The properties and propagation of electromagnetic fields, electromagnetic potentials, and the field in a moving system are the subjects of the earlier chapters. Later chapters deal with electric circuits and transmission lines, waves in homogeneous and continuous media, reflection and diffraction, wave guides, and resonant cavities. Essentials of vector and tensor calculus, Fourier series and integrals, and the principle of the stationary phase are covered in a mathematical introduction.

ELEKTRISCHE STOSSFESTIGKEIT. By R. Strigel. Springer-Verlag, Berlin, Germany, second edition, 1955. 397 pages, 6½ by 9¼ inches, bound. DM 43.50. Intended for electrical and research engineers, this text provides an up-to-date treatment of surge-voltage breakdown strength. The three main sections cover the physics of surge-voltage breakdown in air, oil, and solid insulation; the measurement of surge-voltage breakdown; and the surge-voltage resistance of electrical plant and apparatus, including the testing of electrical machines and transformers.

THE FORESEEABLE FUTURE. By Sir George Thomson. Cambridge University Press, 32 East 57th Street, New York 22, N. Y., 1955. 166 pages, 5 by 7½ inches, bound. $2.50. A forecast, by an eminent British scientist, of the technical advances that are likely to be made in the fields of power, materials, transport, communications, weather, food, and biology by the further development of presently known scientific principles. The social consequences of the changes foreseen are also discussed, and one chapter, on artificial and natural thought, deals with such subjects as future applications of computers and possibilities for improving the human brain.

INTRODUCTION TO MODERN PHYSICS. By F. K. Richtmyer, E. H. Kennard, and T. Lauritsen. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., fifth edition, 1955. 666 pages, 6 by 9¼ inches, bound. $8.50. Although extensive changes have been made in the preparation of the new edition of this standard text, an effort has been made to retain its characteristic features, especially the historical treatment of new fields and thorough discussion of selected subjects in preference to a general summary of the entire subject. The principal changes include expanded treatment of wave mechanics and spectroscopy, and rewriting of the chapters on nuclear physics and cosmic rays.

INTRODUCTION TO NUMERICAL ANALYSIS. By F. B. Hildebrand. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1956. 511 pages, 6½ by 9¼ inches, bound. $8.50. Covers the basic operations of computation, approximation, interpolation, differentiation, integration, and the numerical solution of equations, as well as applications to such processes as smoothing of data, summation of series, and numerical solution of ordinary differential equations. Consideration is given to error analysis, convergence, and stability. Throughout the book formulas are derived in a manner that illustrates underlying hypotheses and methods of generalization and modification. A bibliography of 276 references is included.

INDUSTRIAL MANAGEMENT. By R. H. Lansburgh and W. R. Spriegel. Fifth edition, revised by W. R. Spriegel. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1955. Various pagings, 6 by 9¼ inches, bound. $6.75. Policies and principles of successful management are presented, with the devices necessary for carrying them out, keeping in mind the needs of both the student and the executive. Throughout the book an effort has been made to show the interdependence of the various major departments of a business. This fifth edition has been revised to cover recent developments in the field, including a new chapter on job evaluation and expanded discussion on inspection processes and quality control. There is a broadly classified bibliography.

THE MATHEMATICS OF PHYSICS AND CHEMISTRY. By Henry Margenau and G. M. Murphy. D. Van Nostrand Company, Inc., 120 Alexander Street, Princeton, N. J., second edition. 604 pages, 6½ by 9¼ inches, bound. $7.95. For the most part, each chapter of this book treats a single mathematical method in a systematic manner and with the degree of rigor customary in careful scientific demonstations. The topics dealt with include partial differentiation as used in thermodynamics, ordinary and partial differential equations, vector analysis, matrices and matrix algebra, quantum mechanics, statistical mechanics, and numerical calculations. Fully worked examples are often used to illustrate the theory under discussion.

NETWORK ANALYSIS. By M. E. Van Valkenburg. Prentice-Hall, Inc. Englewood Cliffs, N. J., 1955. 440 pages, 6½ by 9¼ inches, bound. $13. An introduction to the subject based on the pole and zero approach. The book deals, in the first eight chapters, with various topics in transient analysis, including the formulation of equilibrium equations and their solution by both classical methods and the La Place transform method. Later chapters cover complex frequency, impedance and transfer functions, poles and zeros, and applications to the analysis of reactive and stagger-tuned amplifier networks. The last two chapters are devoted to block diagrams and the stability of feedback systems.

NUMERICAL ANALYSIS. By Zdenek Kopal. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1955. 556 pages, 5½ by 8¾ inches, bound. $12. The main subjects in this book are polynomial interpolation, numerical differentiation and integration, solution of ordinary differential equations of any order or degree for initial-value problems, and solution of linear differential equations of any order for boundary-value problems. The book also contains an introduction to the study of mechanical quadratures and their applications in the numerical solution of integral and integro-differential equations. The aim of the book is to develop the analytical basis of numerical processes used in the solution of problems of the infinitesimal calculus encountered in physics and engineering.

PAMPHLETS

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Correction: The pamphlet entitled "Polyphase Motor Starting Current Rules" is available at 25¢ each from the Edison Electric Institute, 420 Lexington Ave., New York 17, N. Y. We are sorry for any inconvenience caused by publication of an address which was in error.

X-Ray Protection, Handbook 60. This handbook has been issued by the U.S. Department of Commerce, National Bureau of Standards, and supersedes Handbook *41*, "Medical X-Ray Protection Up to Two-Million Volts" prepared by the National Committee on Radiation Protection in 1949. The word "medical" has been deleted from the present title, as many of the recommendations and suggestions can be used equally well for industrial applications. Handbook *60* is complete in itself and reference by the reader to *H 41* is unnecessary. Although these recommendations are intended primarily for the protection of the radiation worker and the public, rather than of the patient, the increasing use of ionizing radiations makes it necessary for the medical profession to exercise great caution and restraint in the use of these agents. The National Committee on Radiation Protection has established 11 subcommittees, each charged with the responsibility of preparing protection recommendations in its particular field. The present handbook was prepared by the Subcommittee on X Rays Up to Two-Million Volts. This booklet can be ordered from the Superintendent of Documents, Washington 25, D. C. at the price of 20¢ per copy.

Reactor Shielding Design Manual. Edited by Theodore Rockwell, III. This manual is one of a technical series sponsored by the Naval Reactors Branch of the Atomic Energy Commission (AEC). Previously issued manuals cover liquid metals, zirconium, beryllium, and a bibliography of reactor computer codes. Additional manuals are in preparation for corrosion and wear in water-cooled reactors, naval reactor physics design, reactor core design, reactor plant piping, reactor heat transfer, and the metal hafnium. This entire series of manuals is an effective answer to the complaints that declassification procedures are too slow and that release of previously classified documents on a bulk basis provides the specific information seeker with a "needle in a haystack." The Shielding Design Manual contains 10 chapters which cover the entire range of design procedures including the essential theoretical background, and also valuable information on shielding materials and methods of construction. The first chapter presents basic principles including a justification for the neutron removal cross-section concept and a brief discussion of build-up factors for the gamma absorption equations. Specific design procedures are detailed in chapter 3, "Shielding the reactor core" and in chapter 4, "Shielding the reactor cooling system." Permissible radiation levels, biological equivalents and specific applications of tolerances including considerations of access time; power level and local streaming are given in chapter 2. Plant layout factors including distance effect, optimization of primary and secondary shielding, and shadow shielding concepts appear in chapter 5. Chapter 6 provides detailed information on physical and shielding properties of usable materials, fabrication and assembly details, and operational test procedures for measuring radiation levels. A separate chapter (7) is required for the special problems related to safe access after shut down. This chapter includes valuable and previously unpublished information on activation of impurities in the coolant system and studies of possible fission product contamination. Chapter 8 treats the numerous problems of shield penetrations and other irregularities. The final chapters, 9 and 10, provide a summary of the reference mathematics (including derivations) for radiation flux geometry and basic data and curves for build-up factors, absorption coefficients, cross sections and radiation damage summaries. This manual was released in March 1956 by the Naval Reactors Branch, Division of Reactor Development of the AEC and is available at $2.10 per copy from the Office of Technical Services, Department of Commerce.

The American Standard Safety Code for Elevators, Escalators, and Dumbwaiters. The fifth edition of this American Standard by G. P. Keogh has been approved by the American Standards Association (ASA) and is off the press. Work on this American Standard began in 1922 at the request of the American Society of Mechanical Engineers (ASME), which wanted a nationally accepted elevator code. The ASA approved the initiation of this project and assigned sponsorship of the work to the ASME, American Institute of Architects, and the National Bureau of Standards. The committee which actually developed the code represented elevator manufacturers, insurance carriers, government (federal, state, and local), building owners and managers, employees, public interest groups, technical and engineering societies, and others. Always watching for improvements in manufacturing and safety practice, the committee brought the code up to date in 1931, 1937, 1945, and 1955. The latest revision is the combined work of 22 separate subcommittees consisting of from 4 to 20 members each, and representing groups especially interested and qualified to draft regulations in the specific fields to which they were assigned. The total membership of these subcommittees was 150. This publication, *A17.1*, 1955, can be ordered from the American Standards Association, Inc., 70 East 45 Street, New York 17, N. Y. The price is $3.50.

Supervisory Management. This new educational monthly magazine for foremen and supervisors in business and industry, has been published by the American Management Association (AMA). Each issue will contain from 60 to 70 pages of articles designed to improve supervisory efficiency. In addition to contributions from AMA staff members and outside specialists, the magazine will publish appropriate material drawn from the association's meetings. The first issue takes up such subjects as work sampling, grievance handling, production control, motivation of employees, the supervisor's role in community relations, and arbitration. Subsequent issues will stress concrete, usable information to help the foreman or supervisor in plant or office do a better job. Objectives are to sharpen the supervisor's awareness of management problems, broaden his picture of the responsibilities of management, and aid in his personal development. Although the association has been publishing material for executives for 32 years, *Supervisory Management* is its first periodical directed to the supervisor. Individual and company bulk subscriptions are available both to members and nonmembers of AMA. Subscriptions are $6.50 per year for members of AMA, and $7.50 for nonmembers. Additional information may be obtained by writing C. W. McDowell, director, Supervisory Development Services, American Management Association, 1515 Broadway, New York 36, N. Y.

Professional Engineer's Examination Questions and Answers. With the questions and answers in this authoritative guide, candidates for engineering licenses get the closest possible idea of what the real examinations are like and what they must know to pass. This selection of over 500 questions was drawn from recent actual examinations for Professional Engineer License, Land Surveyor License, and Engineer-in-Training Certificate. For every question there is a detailed answer of the type that examiners accept and credit. Questions cover all major phases of professional engineering examinations. There are questions in fundamental engineering, and in chemical, civil, electrical, and mechanical engineering. Many are composites of the more complex questions found in professional engineering examinations all over the United States. Thus, with this publication the license candidate can thoroughly prepare himself for his examination no matter what his field of engineering may be or in what part of the country he will take it. The author, W. S. LaLonde, Jr., draws on long and intimate experience in preparing license examinations. Published, January 1956. 462 pages, 215 illustrations. $6.50. Further details are available from McGraw-Hill Book Information Service, 327 West 41 Street, New York 36, N. Y.

Rider's Specialized Hi-Fi AM-FM Tuner Manual. This first volume of a new series by the John F. Rider laboratory staff offers to those interested in the maintenance of these devices, the most elaborate and complete data obtainable. Prominent manufacturers' products, spanning over five years (1950–1955) of production, have been included. The details given for each tuner contain, in addition to descriptions and specifications, those data which are essential to diagnosis and repair, as well as the adjustment information needed for alignment. Operating voltage figures are given, illustations of the chassis, and other changes pertinent to servicing. The information contained in this series has been procured directly from the manufacturer of each product and is, consequently, the most accurate available. 8½ by 11 inches, paper bound. 208 pages. $3.50. Further information may be obtained from John F. Rider Publisher, Inc., 480 Canal Street, New York 13, N. Y.

Interchangeability Directory of Industrial-Type Electron Tubes, Form 1D-1020A. and Picture Tube Replacement Directory, Form KB106. "The Interchangeability Directory" lists 2,000 tube designations presented in a form that is of maximum assistance to distributors, dealers, servicemen, broadcast stations, and individual tube users in selecting the proper Radio Corporation of America (RCA) tube type as a replacement. Included in the listings are vacuum power tubes, vacuum and gas rectifiers, thyratrons, ignitrons, magnetrons, cold-cathode (glow-discharge) tubes, phototubes, oscillograph tubes, camera tubes, and receiving type tubes for industry and communications. Tubes of 26 manufacturers are indexed. "The Picture Tube Replacement Directory" is divided into two parts. The first section lists the ratings and characteristics of 60 existing picture-tube types, including the *15GP4* and *21AXP22* color tubes, and 13 discontinued RCA types. The second section lists recommended RCA replacements for more than 150 industry types. Copies of the publications may be obtained from RCA tube distributors or from Commercial Engineering, RCA Tube Division, Harrison, N. J., at a cost of 20¢ per copy.

Proceedings. This publication of the second annual Computer Applications Symposium held October 24–25, 1955, at Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill., is available. Copies of the proceedings may be obtained by sending $3 to: Harold H. Kantner, Electrical Engineering Research Department, Armour Research Foundation of Illinois Institute of Technology, Technology Center, Chicago 16, Ill.

Radio Philatelia. Herbert Rosen has written a book offering a new approach to a most fascinating topical subject. The development of telecommunications is traced from its inception to the present day, exclusively through the medium of postage stamps. Each page is devoted to another phase of radio or broadcasting, listing stamps dedicated to different radio stations, broadcasting buildings, microphones, as well as stamps commemorating radio conferences, congresses, and electronic exhibitions. Stamps featuring the use of radio in the air, radio at sea, radio at war, radio and meteorology, radio in the Arctic and Antarctic, as well as stamps with a television theme are listed under specific categories. All the famous men who made the medium of radio possible are included: Otto von Guericke, Volta, Ampere, Popov, Morse, Marconi, and others too numerous to mention here. Every aspect of radio or broadcasting is thoroughly covered. This book is published in English, French, and German, and all stamps are listed in the four leading international catalogues: the American, Scott; English, Gibbons; French, Yvert; and the German, Michel. The book contains listings of over 500 stamps, as well as several hundred postmarks and slogans; there are almost 300 illustrations reproducing all stamps in their original size. $2. For further information write to Audio-Master Corporation, 17 East 45 Street, New York, N. Y.

Guide to Instrumentation Literature. This publication by W. G. Brombacher, J. F. Smith, and L. M. van der Pyl is intended to assist research investigators, instrument users, and others interested in utilizing the extensive and scattered literature of instrumentation. It was prepared as part of the program of instrumentation research and development which is co-operatively sponsored by the National Bureau of Standards by the Atomic Energy Commission, the Office of Naval Research, and the Air Research and Development Command. This program is administered by the Office of Basic Instrumentation. 156 pages. Price $1. To order, write to Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

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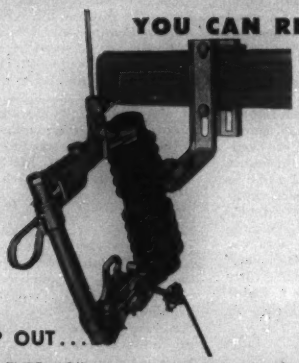

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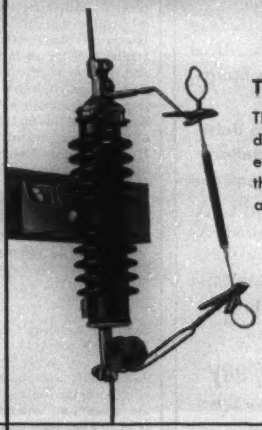

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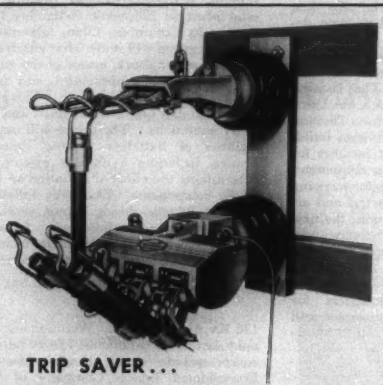

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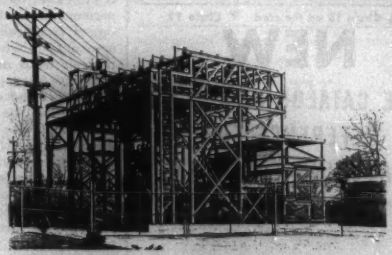

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GENERAL ELECTRIC

INDUSTRIAL NOTES ...

Honeywell Plant in Amiens, France. In a further foreign operations expansion, Minneapolis-Honeywell Regulator Company has started construction of a small plant at Amiens, France, to produce oil burner controls for that country's growing oil heating market. This will be the fifth Honeywell plant outside the United States. It also will be an industrial milestone for Amiens because the plant will represent the first foreign industry to establish manufacturing operations in that city. Commemorating this fact, the Amiens Chamber of Commerce presented a special medal to H. W. Sweatt, Honeywell's board chairman. The Amiens plant will produce primarily for the French market, but some of its output will probably also be exported to other European countries. The domestic oil heating market began developing after World War II when oil became available for home heating from the new French refineries.

Bendix Aviation Expanding. Bendix Aviation Corporation has started construction of two new facilities at the Palmdale, Calif., aviation center for the testing and servicing of equipment for military air bases and manufacturers of jet aircraft. The buildings will be the first permanent installations of their type designed specifically to serve the booming aeronautical industry and network of military air fields in the Mojave Desert and adjacent Antelope Valley. The installations are being constructed by the Utica Division and the Bendix Products Division of Bendix. The Products Division building will house shop and test facilities for fuel metering and landing gear equipment. The Utica Division building is for servicing and testing of combustion starters and air turbine accessories. In addition, the new facilities will give service and test support to equipment in use at Edwards Air Force Base, the Navy's Mojave Air Station, George Air Force Base, and Nellis Air Force Base. Administration headquarters for Bendix West Coast sales and service will remain at 117 Providencia Street, Burbank, Calif.

Twin Press Installed. A twin press for bending large boiler drum half shells has been installed at the Barberton, Ohio, works of The Babcock and Wilcox Company (B and W). The press, designed and built by B and W employees, will double the plant's plate bending capacity. The new press has a capacity of 5,000 tons and stands over 25 feet high. Four giant manipulator hooks powered by independent hydraulic circuits are used to place hot plates into position on the press. Each hook will lift 35 tons and is controlled by electric push buttons from either of two control consoles. A portable control box is provided for handling cold plate for final sizing operation.

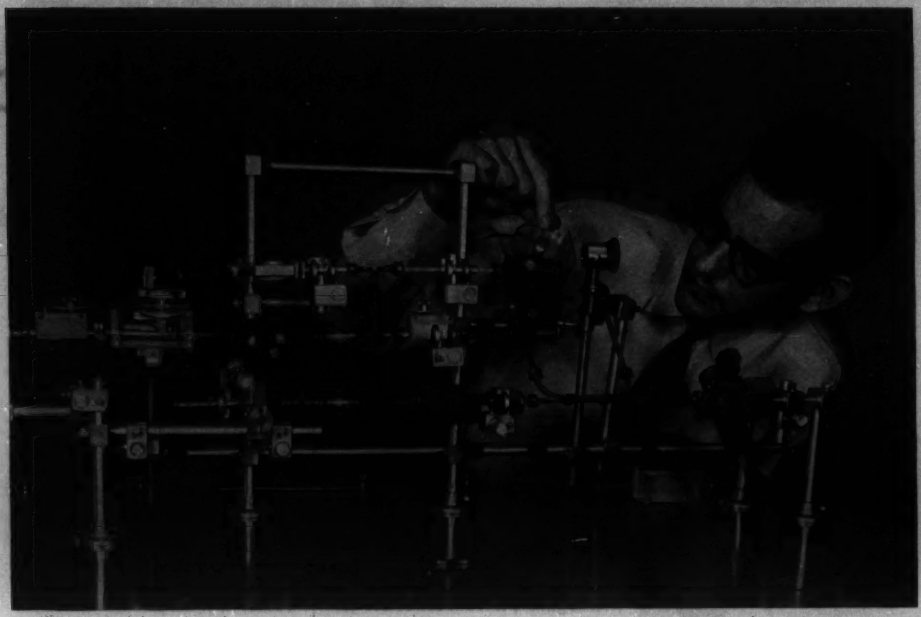
White Industries Changes Name. White Industries, wholly owned subsidiary of Mack Trucks, Inc., has become Mack Electronics Division, Inc. Robert Edwards will continue as general manager. White Industries was acquired by Mack in 1955. The Mack Electronics Division, Inc., manufactures gunfire control, radar, missile-tracking, and laboratory test equipment. It also produces and conducts extensive research into other complex electronic developments. For further information contact John Deitrick, Mack Trucks, Inc. 350 Fifth Avenue, New York 1, N. Y.

Electro Engineering Moves. Electro Engineering Works, Inc., one of San Francisco's major producers of transformers for the electronics and public utilities industries, moved to 401 Preda Street in San Leandro, Calif., a new industrial tract bordering the city of Oakland. The new structure will permit the further expansion to triple the present size of facilities.

Electronic Reliability Division at Battelle. As a result of increasing demands for research on electronic components and systems, Battelle Memorial Institute has established an Electronic Reliability Division at its Columbus, Ohio, laboratories. The new group will study what effects high altitude, severe shock, humid or dry atmospheres, extreme temperatures, and acceleration have on performance. There will also be studies under sand, dust, and salt spray conditions. The group will use the facilities of Battelle's Atomic Research Center, including a nuclear reactor, for determining the effect of radiation on electronic components. Electronic reliability work at Battelle during recent years has tapped numerous technologies. In addition to electronics, these have included ceramics, metallurgy, operations research, plastics, and others.

138 Kv Air Breakers. Westinghouse will manufacture 11 additional 138-kv outdoor compressed-air circuit breakers for the Consolidated Edison Company of New York, Inc., New York, N. Y. This utility ordered 11 similar breakers from Westinghouse in 1955. They are the first outdoor compressed-air breakers of this rating to be built for an electric utility by an American manufacturer. The breakers have an interrupting capacity of 10-million kva and will be of the dead metal tank design. Air pressure will be approximately 250 pounds per square inch. Installation will be at the Arthur Kill, Astoria, and North Queens Stations in New York City, in 1957. Inasmuch as they will be applied in highly congested areas, the use of compressed-air breakers is preferred over the oil filled designs previously used. Many of the

(*Continued on page 18A*)



Physicist G. K. Farney checks the frequency of Bell's new klystron, which is located at far right. Tube's output is about 20 milliwatts.

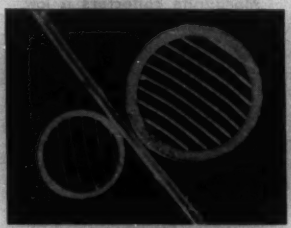
Sixty billion vibrations per second

A great new giant of communications—a waveguide system for carrying hundreds of thousands of voices at once, as well as television programs—is being investigated at Bell Telephone Laboratories.

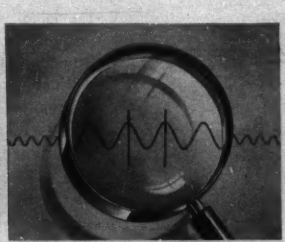
Such a revolutionary system calls for frequencies much higher than any now used in communications. These are provided by a reflex klystron tube that oscillates at 60,000 megacycles, and produces waves only 5 mm. long.

The resonant cavity that determines the frequency is smaller than a pinhead. The grid through which the energizing electron beam is projected is only seven times as wide as a human hair, and the grid "wires" are of tungsten ribbon 3/10,000 inch in width.

G. K. Farney, University of Kentucky Ph. D. in nuclear physics, is one of the men who successfully executed the development of the klystron. Dr. Farney is a member of a team of Bell scientists whose exciting goal is to harness the immense bandwidth that is available with millimeter waves . . . and to make certain that your telephone system remains the best in the world.



Grids in new tube, enlarged 30 times, with human hair for comparison. Electronic beam passes through smaller, then larger, grid.



Wavelengths produced by the klystron tube are only .2 inch long—1/15 that of the transcontinental radio relay system.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH

For more information circle 12 on reader service card.

They Go a Long Way

Morganite current collectors go a long way toward cutting expenses for crane operation and maintenance. The wear-resistant carbon inserts in **Morganite collectors** offer you a triple saving through . . .

- **LOW COST**
- **LONG LIFE**
- **LOW WIRE WEAR**

The initial cost of **Morganite collectors** is low. Maintenance is even less. Low-friction carbon inserts actually protect your wires as well as make highly efficient electrical contact. Dangerous arcing is eliminated, and precise control is possible throughout the long life of the collector.

You will find **Morganite current collectors** available for installation on a wide variety of cranes in mills and all types of heavy industrial plants.

50th ANNIVERSARY 1906 · 1956

Morganite INCORPORATED

Manufacturers of fine carbon-graphite products for fifty years.
3308 48th Avenue, Long Island City 1, New York

▲ Circle 13 on the card.

Industrial Notes

(*Continued from page 16A*)

breakers will be arranged for accommodating 138-kv isolated phase bus, the first installation of this type in this country.

Nonfading "Gold" Aluminum. A method of producing nonfading "gold" aluminum in a variety of shades and tones has been developed by Kaiser Aluminum and Chemical Corporation. Source of the color is built into the metal itself. The color is brought out, without use of dyes or other coloring agents, by anodizing under readily controlled conditions. The gold color may be varied from pale straw to deeper gold and gold-bronze tones, and the finish may be either bright or satin. The new process, protected by patent rights of the corporation, imparts a sunfast gold color and provides excellent color matching. Because of the permanence of its color, the new Kaiser gold aluminum is especially suited for a wide range of exterior architectural applications, automotive trim, furniture, and home appliances. It is expected that normal practice in most applications will be to form the metal and fabricate the product or component prior to anodizing. The new gold finish increases corrosion protection and resistance to wear, and withstands boiling water temperature without color loss.

Plant Purchased. The Okonite Company, Passaic, N. J., has purchased the 160-acre Studebaker-Packard plant at New Brunswick, N. J., in an expansion move. Eventually, more than 1,000 workers will be employed at the plant purchased from Volkswagen of America, Inc., a subsidiary of Volkswagenwerk GMBH, German automobile manufacturers, who had bought the plant from Studebaker-Packard. Operations at the new plant will be confined to manufacturing only.

Kaiser Aluminum Exhibit Trailer. A specially designed trailer for exhibiting Kaiser Aluminum electrical conductor products has been built for Kaiser Aluminum and Chemical Sales, Inc., which will be displayed as part of the company's electrical conductor sales program. Six sliding display panels may be pulled out for close inspection of a full range of electrical wire and cable products. The trailer will also serve as a mobile laboratory for demonstrating proper and improper practices in the use of

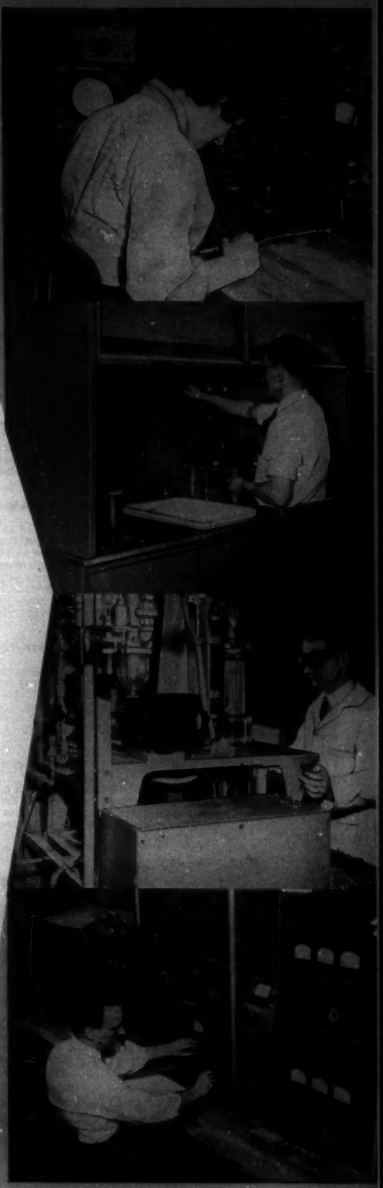
Kaiser Services Photo

(*Continued on page 20A*)

Circle 14 on the card. ▶

ATTENTION!
designers and
manufacturers

interested in
SILICON *and*
GERMANIUM
devices?



From raw materials to finished product, all processes are under our rigid control to ensure uniformity and high quality. We have the "know how" and facilities for making Transistors and Diodes to meet your specific requirements. We can render assistance in basic circuit design problems. Let us help you.

WRITE

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Northern Electric
COMPANY LIMITED

ST. JOHN'S, NFLD. HALIFAX SYDNEY MONCTON SAINT JOHN, N.B. FREDERICTON CHICOUTIMI QUEBEC CITY TROIS RIVIERES SHERBROOKE ROSEMON
MOUNT ROYAL MONTREAL OTTAWA VAL D'OR KINGSTON TORONTO O'CONNOR DRIVE KITCHENER HAMILTON ST. CATHARINES LONDON SARN
KIRKLAND LAKE WINDSOR TIMMINS SUDBURY SAULT STE. MARIE PORT WILLIAM WINNIPEG BRANDON REGINA SASKATOON MEDICINE HA
LETHBRIDGE CALGARY EDMONTON TRAIL PENTICTON VERNON PRINCE GEORGE NEW WESTMINSTER VANCOUVER VICTOR

BURNDY Co... modern research techniques with product leadership

When a company's products are as important to almost every segment of American industry as BURNDY electrical connectors, those products have to be good. And because BURNDY connectors are only as good as their performance in actual operation, the BURNDY laboratories incorporate the very latest design and manufacturing research techniques to produce connectors that surpass requirements in every way.

The BURNDY laboratories use many scientifically accepted test techniques and quality control procedures during both product development and production random sampling.

◀ RELATIVE CONDUCTIVITY

Laboratory technicians use a Kelvin Bridge to measure to the nearest microhm electrical resistance across the connector joints, and compare readings with equal lengths of uninterrupted cable.

SALT SPRAY TESTS ▶

Connector-joint stability is evaluated by submitting the sample joint to strict Federal Specification tests. A 20% solution of common salt in water at 100° F is atomized by means of air pressure, creating a highly corrosive vapor fog. After the required length of time, a Kelvin Bridge measurement is again taken. The findings prove invaluable in creating corrosion-resistant connector designs.

◀ VIBRATION CYCLING

Many Burndy connectors are designed for rotating machinery and in trains, cars and aircraft. BURNDY carefully tests the prolonged effects of vibration. Kelvin Bridge measurements determine vibration stability, and determine any tendency toward fatigue failure.

HEAT CYCLING ▶

Controlled cycles subject the connector alternately to an on-and-off overload test current. Kelvin Bridge measurements taken during this process determine the temperature rises that occur in the electrical joint and in the cable, thus establishing the electrical stability of the joint.

◀ TORQUE TESTING

Clamp-type and split-bolt connectors are subjected to torque tests. Connectors are tightened with a turning force sufficient to cause failure of the hardware or of the connector itself. Maximum connector strength measurements as well as valuable design information is secured.

TENSION TESTING ▶

Where full tension is required, the cable must break before the connector fails. Most applications do not require this extreme, and tension requirements are established according to the connector's final use.

BURNDY specializes in only one field—that of making better electrical connectors. BURNDY's special talents are available to all industry. Whatever your electrical connector need, BURNDY has the experience and the facilities to serve you. That is why for over a quarter of a century BURNDY has been the leader in its field.

For further information, or assistance on your particular problem, write to . . .

BURNDY

NORWALK, CONNECT.

▲ Circle 13 on the card.

Industrial Notes

(Continued from page 18A)

aluminum conductor. An electrical test panel dramatically shows the relative resistance of various weatherproof coverings such as asphalt saturated cotton, neoprene, and polyethylene, when applied to aluminum and copper conductors under overload conditions. Spectators may participate in the tests by operating the timing mechanism as the coverings are actually burned through.

Other trailer equipment includes a 5,500 watt motor generator, public address system, and tape recorder.

AGE Company Expands. The largest expansion in the American Gas and Electric Company (AGE) system, which provides electric service to over 4.8 million people in 7 states, will spend $700 million for construction and installation of new facilities during the period 1956–60 was announced recently. This will include the addition of 2.6 million kw of generating capacity to meet the ever increasing demands of the System's 1.3 million customers. This is more capacity than is presently available in any one of 33 states. The 2.6 million kw program will raise the AGE system's total generating capability to 6.6 million kw by 1960, more than double the system's capacity in 1952, and more than triple its 1949 capacity. A total of 1.7 million kw of the expansion is already under construction; this phase will be completed in 1956–58. The balance, the details of which are as yet unannounced, will be commenced by the middle of 1956 and completed in 1959–60. The new 2.6 million kw program comes on top of a previous 10-year construction program, just ended, which involved capital expenditures of $785 million and added 2.245 million kw of capacity.

Navigation System in Desert Test. A radiowave "grid" system that can provide a continuous, all-weather flight position picture for helicopters, other aircraft, sea-going vessels, and mobile ground units, was tested in southeastern Arizona. This Decca Navigation System was developed in England during World War II and is now in use in an area 1,500 miles long from northern Sweden to Spain, giving unbroken navigational coverage and traffic control to the aircraft, the navies, and the merchant marine of a dozen nations. It uses low-frequency radio signals in contrast to the high-frequency pattern used in conventional cross country aircraft navigation. These signals surround a building or mountain like the atmosphere, and there are no electronic shadows or blind spots. American rights to the Decca system were obtained in 1954 by the Pacific Division of Bendix Aviation Corporation, North Hollywood, Calif. The Bendix-Decca system transmits its low-frequency radio waves as a continuous chain from a main transmitter and its "slave" stations, spaced 70 to 100

(Continued on page 22A)

DEPENDABILITY

...EVEN WITHOUT STANDBY... WITH RCA MICROWAVE

IN VITAL 2-SYSTEM OPERATION AT EL PASO NATURAL GAS CO.

The dependability and flexibility of RCA CW-20 Microwave equipment have been demonstrated at El Paso Natural Gas Co. An original 290-mile pipeline installation in Texas, in 1953, has more recently been augmented by a newer 475-mile system in western Texas and New Mexico . . . achieved with a minimum of expense.

According to the Superintendent of Communications of El Paso Natural Gas Co., outage time has never been more than 1%—without standby and wholly without overtime maintenance. In addition, it has been possible to rearrange the systems to fit new requirements as they arise.

The original installation with short-haul leg circuits was used for voice channels and telemetering. Because of its reliability, additional channels were added, and RCA Equipment was chosen for the second installation.

Routes of El Paso Natural Gas Co.'s pipeline microwave systems in mountainous regions of Texas and New Mexico, and (below) microwave antennas on mountain.

RCA MICROWAVE assures the most advanced engineering features. Provision for the addition of future channels makes it the least expensive form of communication per channel mile. Equipment utilizes easy-to-service familiar circuits and conventional tubes. Single side-band suppressed carrier frequency division multiplexing is used exclusively to meet high standards of dependability. Frequency is controlled only from the terminals through the entire system. Furthermore, RCA provides the nation-wide services of the RCA Service Company to keep entire system operating at its peak.

RCA Microwave Specialists will be glad to answer any questions and help plan your installation. Mail coupon for further particulars on use of Microwave in utilities, pipelines, turnpike and other applications.

RCA MICROWAVE
POINT-TO-POINT COMMUNICATION

RADIO CORPORATION of AMERICA
COMMUNICATIONS PRODUCTS
CAMDEN, N. J.

Radio Corporation of America
Communications Products, Dept. E-42
Building 15-1, Camden, N. J.

Please send me latest literature on RCA Microwave.
☐ Have an RCA representative contact me.

NAME _____ TITLE _____
COMPANY _____
ADDRESS _____
CITY _____ ZONE _____ STATE _____

180° C. operation

makes transformers smaller... helps missiles gain range

Problem: Design a set of different transformers for a missiles program. Make them as light and as small as possible. Make them to operate for at least 500 hours in an ambient temperature of 125° C. Make them to withstand 100 G shocks. Make them *fast.*

Solution: We made them light and small, with new bracketry design to meet the shock-resistance requirement.

The transformers are so small, they run hot—as hot as 180° C.

They operate for the specified life, thanks to Class H insulation, special high-temperature wire, solder, etc. —thanks especially to their silicone rubber encapsulation.

Fortunately, we were able to make them quite fast—for this was a "crash" program. Samples were ready in *three to five weeks,* followed by full production in three months.

When *you* need transformers—by hundreds or thousands, straightforward or special design—make use of our engineering and production facilities and experience. We can do your MIL-T-27A qualification testing too.

CALEDONIA

ELECTRONICS AND TRANSFORMER CORPORATION

Dept. EE-5, Caledonia, N. Y.

In Canada: Hackbusch Electronics, Ltd.
23 Primrose Ave., Toronto 4

▲ Circle 17 on the card.

Industrial Notes

(Continued from page 20A)

miles apart. The radio waves form a precise grid pattern ranging from sea level to extreme altitude. Each chain covers an area of approximately 175,000 square miles. The Army initiated the evaluation tests of the Decca system. They will be augmented by tests in behalf of the U. S. Air Navigation Development Board. Results of the tests will be used to determine the system's applicability. Evaluation data also will be made available to the commercial airline industries, helicopter service industries, and marine shippers through the department of commerce. A helicopter installation of the navigator system, including the flight log automatic plotter plus dial-reading position indicators, is expected to weigh about 36 pounds. Helicopters and fixed-wing planes based at Libby Army Air Field, Fort Huachuca, Ariz., will be used in the initial phases of the Signal Corps tests.

NEW PRODUCTS

Rectilinear Recording Milliammeter. The first rectilinear recording milliammeter has been announced by Texas Instruments Inc. (TI). All the advantages of rectilinear recording, with signals presented in their true rectilinear appearance, removing the necessity of complicated data reduction, are combined in this ruggedized, ink-writing, galvanometer-actuated instrument, with front access for all routine operations. Included are front-located signal terminals (rear terminals optional), front-located switches and controls, writing area on chart for notations, disappearing sliding door, front-located zero adjust, front-filling inking system, swinging chart paper carriage, accessibility to perform all routine maintenance and adjustment procedures without removing case or disassembling, and finger-

tip "gear-shift" for changing chart speeds. The rectilinear recording milliammeter weighs less than 27 pounds and occupies less than 3/4 cubic feet. Electrical characteristics are as follows: 1 milliampere for full-scale deflection, 4 1/3 inches active chart width, 1,500 ohms input resistance, and undamped natural frequency of 2 cycles per second. Structurally, the TI recorder consists of interchangeable unit subassemblies mounted on a basic frame which simplifies addition of accessories, modification, or maintenance. The 100-foot chart roll can be run at a choice of 10 speeds, in inches per minute or inches per hour, making possible continuous recordings ranging from 1 hour and 40 minutes to 60 days. Six inches of chart length are always visible, representing as little as 30 seconds or as much as 8 hours, depending on chart speed. The paper feed mechanism has an automatic chart takeup in case the operator wishes to examine more than the normal 6 inches while the instrument is recording. Two event marker pens are available and indirect lighting of the chart is provided for convenience in night recording. TI rectilinear recording milliammeters can be operated from a-c, d-c, or spring-drive. Adapters are built in for external drive.

Item 18 on the card.

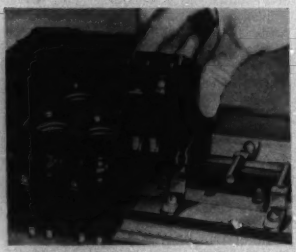
Copper-Clad Laminates for Printed Circuitry. Using a special bonding technique, International Resistance Company, has succeeded in cladding a nonadherent polymer, fluorocarbon plastic, with copper. The resulting new laminate, in which no resin adhesive is used, features very low cold flow, zero water absorption, excellent machinability, and a water-repellent surface. Also, it is unaffected by acids, alkalies, or common organic solvents. Fluorocarbon plastic is a thermoplastic material, and is inherently less rigid than thermosets—especially in thin sections. This copper-clad laminate is recommended for use under severe temperature, moisture, and electrical conditions.

Item 19 on the card.

Glass Yarn. A recent development in the manufacture of glass yarn, in which a coating of Du Pont's Teflon is directly applied to the glass has been announced by the L. O. F. Glass Fibers Company. Previously, glass yarn was braided and then coated with the Teflon. Now, with this coating applied directly to the glass before braiding, each strand of glass gets individual protection, in addition to the over-all protection. The new yarn, being much more abrasion resistant and slippery, is of considerable advantage in the aircraft industry, where aircraft cables have to be pulled through small and sometimes rough openings. It also is used in Navy cable, coaxial cable, and as a sewing thread to fabricate items where chemical resistance is desired. The new yarn is inert to solvents and almost all corrosive chemicals, and has a water absorption so low that it can be considered zero. Nominal ignition loss is 12 per cent.

Item 20 on the card.

Fusible Service Equipment with Plug-in Construction. Square D Company has introduced fusible service entrance devices with plug-in construction which makes it possible to obtain the proper circuit combination for any job, regardless of the number of 110 and 220 volt loads needed. Basic devices are available with a 200 ampere main pullout and space for 28 or 40 plug fuse branches. Plug-in branch



circuits are of two types, plug fuse, or 30 and 60 ampere pullouts. Pullouts are designed to fit the space of 4 plug fuses and any combustion of pullouts and plug fuses is available. This provides the maximum flexibilty necessary to meet large residental and small commercial requirements which required smaller capacity fusible devices or costly panelboard. Fusible service equipment with plug-in construction offers a flexible, economical device for low cost jobs and is Underwriters' Laboratories approved.

Item 21 on the card.

Hand-Held Probe Pyrometer. The Pacific Transducer Corporation has announced a new hand-held probe pyrometer, for use in all types of noncorrosive metallic and nonmetallic liquids, and in atmospheres of furnaces, kilns, ovens, and other high heat containers. Special features are its lightness and portability, ruggedness for use in heavy service, fine balance for constant hand use, bright chrome-plated case and handle, reflective surfaces that prevent absorption of heat, and a calibrating thermometer built into the unit which is positioned in the immediate vicinity of the cold junction, thus providing a more accurate means of calibration. The thermocouples are refractory bead insulated of the closed end type. The probe is 19 inches in length and comes in two types. The chromelalumel couple has a range of 2,300 F (1300 C), and the iron constantan couple has a range to 1,600 F (800 C). The thermocouples may be easily replaced. The D'Arsonval Meter movement has an adjustment screw for cold junction temperature.

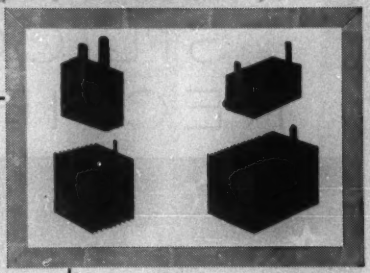
Item 22 on the card.

7-Day Time Switch. A General Controls 7-day time switch, 5*B*, automatically regulates a complex weekly program in-

(*Continued on page 24A*)

Investigate The Cost and Performance Advantages You Can Get with . . .

SYNTRON



- Vacuum Process Insures Uniform, High Quality
- Lowest Forward Voltage Drop Means Greater Efficiency
- Extremely Slow Ageing Results In Extended Life
- Greatest Range of Cell Sizes In The Industry—From 1" Square to 12" x 16" Plates
- Installations In Actual Operation Range Up To 600 KW

SELENIUM RECTIFIERS

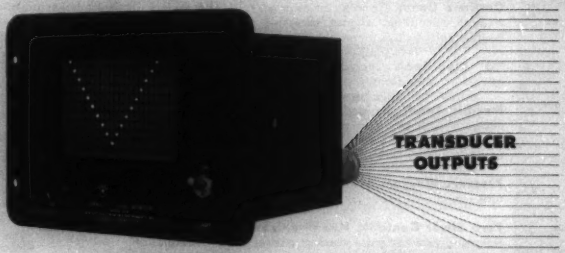
Approved salt spray and fungus resistant finishes available

Write today for complete performance and specification data—Free

SYNTRON COMPANY
440 Lexington Avenue Homer City, Penna.

▲ Circle 23 on the card. ▼ Circle 24.

Century MODEL 20 VISUAL MONITOR



For TEMPERATURE PRESSURE VIBRATION FLOW RADIATION COLORIMETRY CURRENT VOLTAGE

Does your data problem include any of the above? Or anything similar?

The Model 20 Visual Monitor is a completely new concept in multiple data-point indication.

Now you can observe and measure 24 separate data points, simultaneously. No Switching, no commutating, no time lag.

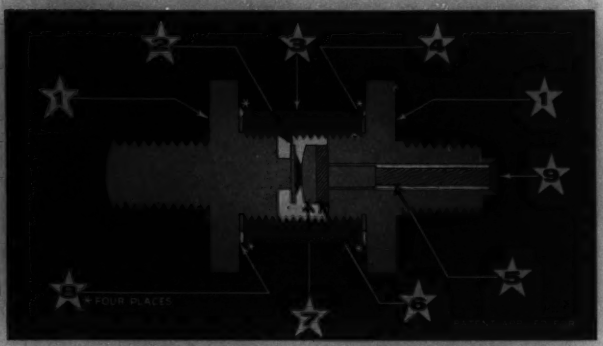
Wherever a graphic display of several quantities will facilitate measurement and control, the Model 20 should be considered.

Utilizing light-beam D'Arsonval galvanometers as the indicating elements, the Visual Monitor permits display of transducer output in an easy-to-interpret, graphic form.

Let us hear from you. We would like to discuss your instrumentation problems with you.

Century Electronics & Instruments, Inc.
1333 No. Utica, Tulsa, Oklahoma

FABULOUS
SILICON RECTIFIER



(Sketch is from 3 to 30 times normal size)

1 **Heat Sink:** Heat sink designs provide optimum cooling with minimum space requirements for higher current ratings. On "double-stud" designs the rectifiers can be mounted with either plus or minus polarity to the chassis, provided convection ratings are followed, thereby eliminating insulation problems on half wave applications.

2 **Silicon Cell:** Special process produces best forward to reverse ratios available with extremely long life.

3 **Ceramic Case:** Capable of high altitude operation without flashover and in high humidities without excessive surface leakage. Mechanically rigid because of positive screw thread design.

4 **"O" Ring Seal:** Special seal design provides hermetic sealing under all operating conditions.

5 **Flexible Lead:** Braided copper leads provide maximum current carrying capacity with minimum mechanical stress during thermal cycling and under acceleration and shock. Pure copper assures an excellent thermal path to assist in cooling.

6 **Pressure Washer:** A positive contact is maintained over the entire temperature range and under all mechanical shock and vibration conditions.

7 **Pure Silver Contact:** Pure silver is used to eliminate contamination, migration, and provide good thermal and electrical conduction.

8 **Mechanical Seal:** A double guarantee that the rectifier assembly is hermetically sealed under all conditions.

9 **Solder Seal:** This provides a seal where the lead feeds through as well as a positive electrical and thermal connection between cell and case or heat sink.

10 A complete range of ratings is available. Three basic case and cell sizes with six connection variations on each provide the design engineer with extreme flexibility of design. Whatever your requirements for dc power, consult us for prompt recommendation.

SARKES TARZIAN, Inc.,
Rectifier Division
DEPT. E-2 415 NORTH COLLEGE AVE., BLOOMINGTON, IND.
In Canada: 700 Weston Rd., Toronto 9, Tel. Murray 7535
Export: Ad Auriema, Inc., New York City

▲ **Circle 25 on the card.**

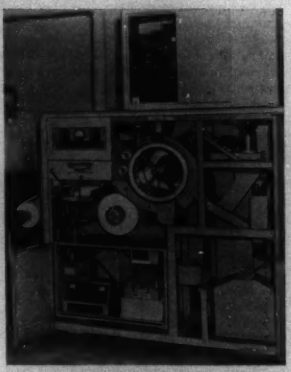
New Products

(Continued from page 23A)

volving from 1 to 6 daily on-off operations. It provides accurate, automatic on-off control of heating, ventilating, and air conditioning systems. Applications include on-off switching of store window and neon display lights, attic fan, refrigerator defrosting, factory floodlights, hall and stairway protective night lights, etc. Each day's schedule, which may be varied or omitted, is independent from every other day's schedule. The switch is available with self-starting, synchronous motor, or powerful 7-day hand-wound spring for use on odd voltages or where power interruptions make synchronous motor timing undesirable. Manual operation will not change subsequent automatic periods.

Item 26 on the card.

Xerographic Service Offered. The Haloid Company has announced establishment in Chicago of the XeroX Processing Laboratories which now offer a xerographic service to blueprint, photocopy, and microfilm firms. The service is made possible by a new type of copying machine, called a XeroX Copyflo Continuous Printer, which



makes enlargements from microfilm. Using the dry, electrostatic principle of xerography, the Copyflo is capable of printing from either 16 or 35 mm film at a speed of 20 feet a minute. The Copyflo equipment takes either perforated or unperforated film, and reproductions may be made from either positive or negative film, but not when intermixed. Maximum print width is 11 inches. There is no minimum, but for practical purposes anything less than $4\frac{1}{2}$ inches is generally not desired. A background density of 1.2, ± 0.2, is recommended for best results. The Copyflo unit has an enlargement range of 7 to 24 diameters. As a practical matter, there would be few instances where a customer would want to enlarge a film at less than 7 or more than 24 times.

Item 27 on the card.

(Continued on page 39A)

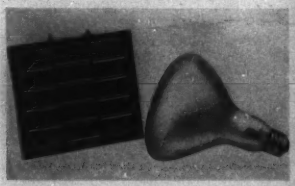
New Products

(*Continued from page 24A*)

Line Shunt Switch. To eliminate soldering, splicing, and taping, a new line-shunt Roto-Glo Quiet Switch has been developed by Pass and Seymour, Inc. Available in Despard or strap-type models, the Roto-Glo is manufactured with screwless terminals to speed installation and cut down labor costs. The new switch mechanism and silver alloy contacts make it possible to install the switch without "derating" for inductive or fluorescent loads. They also guarantee a very low temperature rise and absolutely no oxidation under continuous heavy duty service. Switch mechanism is totally enclosed in plastic and can be mounted in any position. The switches are designed for use with no. 12 or no. 14 solid wire on 15 amp, 120 volt a-c and 15 amp, 277 volt a-c. Size of switch body: $1\frac{23}{64}$ by $\frac{39}{32}$ by $1\frac{9}{32}$ deep.

Item 43 on the card.

Sun Battery. The new International Rectifier Corporation selenium sun battery is a converter of solar energy into electrical

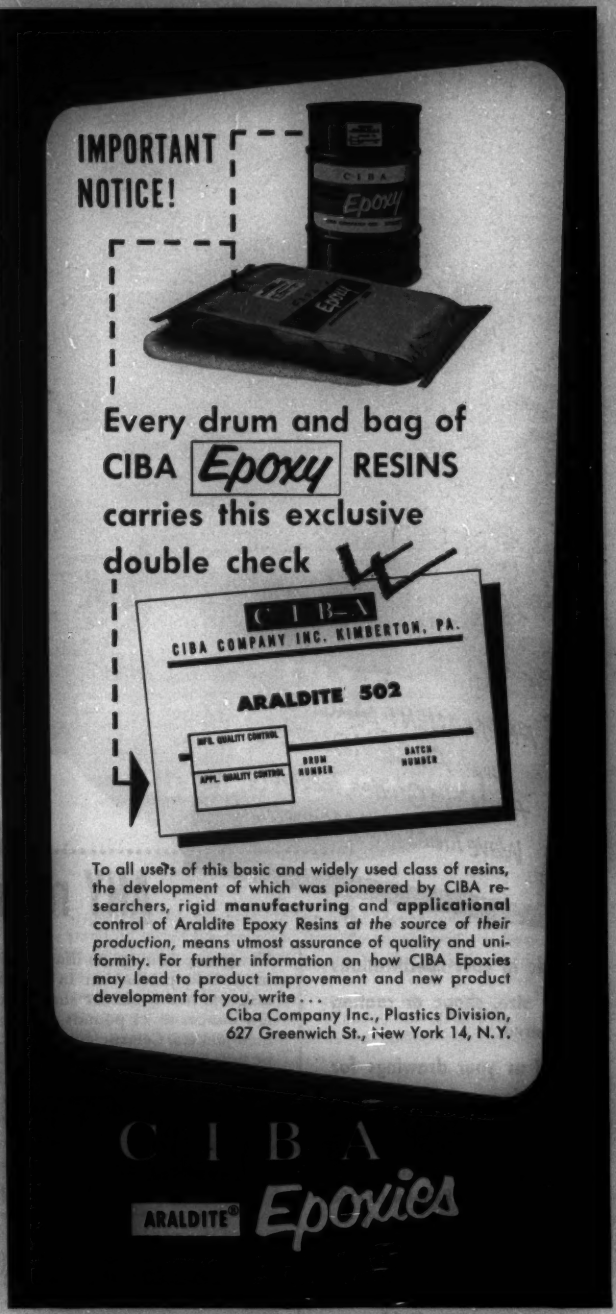


power and is especially designed as a power supply for transistorized devices, such as portable radio receivers and transmitters. Sun batteries may also be used in conjunction with miniature storage batteries to supply continuous power to a lamp. These sun battery products are currently available in production quantities. The battery, consisting of a number of selenium photosensitive elements connected in series, can supply electrical power in the milliwatt range when exposed to sunlight or artificial light.

Item 44 on the card.

Electronic Traffic Watcher. An electronic "eye" to watch and control the flow of highway traffic was demonstrated before a safety meeting. In actual operation the system, developed by Raytheon Manufacturing Company, is set up with a camera located at a number of critical traffic points on highways. The image picked up is transmitted back to a central receiving set, or monitor, by means of microwave links, which require neither wires nor cables. There, traffic observers can switch their receiver from one location to another and, by keeping a close watch on conditions, can be ready to dispatch a patrolman to the scene of any traffic jam the moment it threatens to occur. The equipment is the

(*Continued on page 47A*)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To all users of this basic and widely used class of resins, the development of which was pioneered by CIBA researchers, rigid **manufacturing** and **applicational** control of Araldite Epoxy Resins *at the source of their production*, means utmost assurance of quality and uniformity. For further information on how CIBA Epoxies may lead to product improvement and new product development for you, write . . .
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PERMANENT MAGNETS and ASSEMBLIES for Wave Guides, Traveling Wave Tubes and Magnetrons

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★ Made to your specifications

★ Any size, shape or coating required

★ Send us your drawings for quotation

The group of magnets illustrated above are indicative of the great scope of Arnold production in this field. We can supply these permanent magnets in any size or shape you may need; in weights ranging from a few ounces to 75 pounds or more; and with die-cast or sand-cast aluminum jackets, Celastic covers, etc., as required. Complete assemblies may be supplied with Permendur, steel or aluminum bases, inserts and keepers as specified—magnetized and stabilized as desired. ● Let us handle your magnetron, traveling wave tube and wave guide permanent magnet requirements, *or any other magnetic material specification you may have.*

Write for your copy of Bulletin GC-106A on all Arnold Products

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WSW 3906

THE ARNOLD ENGINEERING COMPANY

SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION

General Office & Plant: Marengo, Illinois

DISTRICT SALES OFFICES . . . New York: 350 Fifth Ave.

Los Angeles: 3450 Wilshire Blvd. Boston: 200 Berkeley

For more information circle 46 on reader service card.

(*Continued from page 39A*)

result of a joint effort by Raytheon and General Precision Laboratories, Inc. (GPL). Raytheon makes the microwave link which picks up the image from the camera and shoots it back to the monitor, while GPL makes the cameras and monitors. For further information write to: Raytheon Manufacturing Company, Waltham 54, Mass.

Item 47 on the card.

Variable Delay Line. The 1-microsecond HELIDEL now joins the family of HELIPOT precision components. It was designed to meet the demand for a precise, passive delay line having a longer total delay than in the 0.2 microsecond and 0.3 microsecond units. Delay is adjustable increments of 0.04 millimicroseconds. Rise time is 0.08 microseconds maximum; frequency response is from 0 to 4.5 mc. Overshoot and phase distortion are negligible. This unit is particularly useful in short-range radar. It is capable of jitter free measurement of signals in the less-than-500-feet range where electronic delays are difficult to obtain and where linearity better than ±5 feet is desirable. Other applications include use in laboratory electronic measuring devices in color telecasting and high speed computers. It is also valuable as a memory circuit in the development of high-speed computers because of the relatively long, distortion free delay.

Item 48 on the card.

Verifax Signet Photocopy Machine. The Verifax Signet Copier, which produces several copies of any document in one minute, has been introduced by the Eastman Kodak Company. Less than the cost of a standard typewriter, the new Copier allows even the smallest business and industrial firms to have photocopying facilities. Its simplicity of operation furthers the trend toward decentralized photocopying. The Signet Copier handles documents up to and including the 8½ by 14-inch legal size. It can be operated in ordinary room illumination. With regular Verifax Copy Paper, up to five or more black-on-white copies are produced at a materials cost of about 2½¢ per copy in the letter size. Suitable papers are also available in card weight, in light-weight for airmail use, and in blue and yellow for color-coding of copies or other special applications. Offset plates suitable for running several hundred copies are produced by this method in about one minute at a cost of 20¢.

Item 49 on the card.

Telemetering Accelerometer. North American Instruments, Inc., has announced the Northam Model *A-7T* accelerometer, a variable inductance transducer for use in FM-FM telemetering systems. It is intended for static and dynamic measurement of linear acceleration and is available in ranges from ±1 to ±100 g. Overloads of 4 times rated range or of 60 g, whichever is greater, will not damage the unit. Standard *A-7T* accelerometers are damped to 0.7

(*Continued on page 56A*)

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TOTAL FAILURE PROTECTION

PARTIAL VOLTAGE FAILURE PROTECTION

POSITIVE NORMAL OR EMERGENCY POSITIONS ONLY

investigate Trans-O-Matic AUTOMATIC TRANSFER SWITCHES

Trans-O-Matic's compact, failure-proof design employs two standard circuit breakers, one from the normal and one from the emergency source, either of which will supply the load. Relay-actuated motor operates circuit breakers for positive mechanical transfer with continuous service in normal or emergency position. Available in capacities to 600 volts, 800 amps, interrupting capacities to 50,000 amps RMS. Prompt delivery in most sizes.

OPTIONAL FEATURES

Adjustable time delay on restoration to 20 minutes • Engine starting contact • Test pushbutton • Pilot lights for switch position • Special enclosures

LAKE SHORE Electric CORPORATION
BEDFORD, OHIO

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Action! on sales service for an Illinois utility by a Kaiser Aluminum sales engineer who delivered vitally-needed accessories in less than 24 hours!

Action! for an Arizona utility when Kaiser Aluminum engineers provided "invaluable" field assistance on an installation of weatherproof!

Kaiser Aluminum services available to you:

Field Service—Experienced Kaiser Aluminum field engineers are available to work with your crews on stringing jobs; demonstrate ways to speed installations and cut costs.

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Laboratory Service—Kaiser Aluminum laboratories continually evaluate accessories, enabling us to suggest accessories and installation procedures designed to give you maximum service and economy. They offer assistance on phases of your operations involving fundamental research. They also continually check Kaiser Aluminum conductor to insure consistent high quality.

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Kaiser Aluminum distributor coverage is the best in the country. There's a distributor conveniently located to serve you, wherever you are. His many services include: large stocks of Kaiser Aluminum conductor, fast delivery to help reduce your inventory, up-to-the-minute information to help keep you abreast of latest developments, friendly, personal attention to any size order.

You get these complete services at no extra cost when you specify Kaiser Aluminum conductor.

For more information circle 51 on reader service card.

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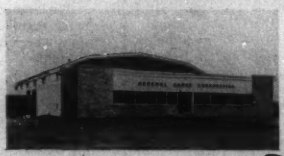
Get your Job done faster

***Backing up** the stocks carried by your **AUTHORIZED GENERAL CABLE DISTRIBUTOR** are large stocks at a nearby **GENERAL CABLE** Distributing Center.*

The result . . . everything you need is readily and quickly available. Specify General Cable.

29 "GENERAL" Distributing Centers Coast-to-Coast.



All these stocks in light traffic locations for fast delivery.

General Cable . . . *at your service!*

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YOU CAN USE INDUSTRIAL TV

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KAY LAB'S small camera flashes images from remote points and dangerous operations to a central location . . .

VIEW: Production schedules, charts, blueprints, gauges, meters, flames, smokestacks . . .

OBSERVE: Gates, loading docks, storerooms, manufacturing operations . . .

USE: For plant tours and training, time and motion studies.

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KAY LAB TV IS UNEQUALLED

for laboratory performance combined with rugged durability, simplicity, economy . . . our nationwide staff of field engineers has experience in hundreds of installations . . .

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▲ Circle 63 on the card.

New Products

(*Continued from page 41A*)

critical over the temperature range −65 to +160 F with silicone oil. The unit is insulated and an internal temperature of 160 F is thermostatically maintained to provide good stability and constant damping regardless of ambient temperature from −65 to +160 F. It will operate in temperatures up to 300 F for short periods of time with no loss of accuracy. The seismic system consists of a mass supported by a cantilever spring; motion of this mass is detected by an E-core-coil arrangement.

The small motions necessary provide a stiff mechanical system which allows a high resonant frequency and excellent frequency response. Since the *A-7T* is intended for use in FM-FM telemetering systems, the electrical characteristics are such that the instrument will operate in conjunction with an inductance type subcarrier oscillator. Two standard types are available; one to operate on No. 4, No. 5, and No. 6 RDB band with nominal inductance of 0.8 henrys and the other to operate on No. 7, No. 8, and No. 9 RDB band with nominal inductance of 0.15 henrys. The Q of both types is greater than 6.

Item 64 on the card.

Tiny Oscillograph Tube. A flat-face oscillograph tube, *RCA-1EP1*, having a diameter of only $1^1/_4$ inches, intended primarily for use in lightweight portable equipment, or in continuous monitoring service for large electronic equipment, has been developed by the Radio Corporation of America Tube Division. The *1EP1* utilizes electrostatic focus and deflection, has a minimum useful screen diameter of $1^1/_{16}$ inches, a maximum over-all length of only $4^1/_{16}$ inches, and weighs 2 ounces. Other design features of the *1EP1* include a separate base-pin terminal for each deflecting electrode to permit use of balanced deflection, and a small button unidekar 11-pin base. The heater of the *1EP1* draws 0.6 ampere at 6.3 volts. The screen phosphor is type *P1* with medium persistence.

Item 65 on the card.

Subminiature Transistor. This tiny electronic device is so small that more than 20 can be placed on a dime. It operates in the audio frequency range and performs the functions of larger size transistors. Named the *M-1*, it can be employed in electronic systems where miniaturization is an important factor, including guided missiles, computers, hearing aids, portable radios,

(*Continued on page 58A*)

NOW . . .
Noise Free
A.C. Power!

NEW CURTISS-WRIGHT
DISTORTION ELIMINATING
VOLTAGE REGULATOR

- Reduces typical power line distortion to less than 0.3%
- Furnishes 1.4 KVA of distortion-free power
- Electronically regulates 115 V output to ±1%
- Recovery time less than 1/50 cycle
- Provides additional 4 KVA of ±1% electromechanically regulated power
- Electromechanical time constant only 0.6 seconds
- Electromechanical regulator, unlike usual magnetic voltage stabilizer, introduces no distortion or phase shift

Here at last is the ideal solution to the disturbing problem of harmonics and low frequency noise appearing in 115 V., 60 cps power sources. In one compact package, every laboratory can now obtain *both*

1) distortion-free, regulated power when needed, and simultaneously

2) a large supply of electromechanically regulated power for applications where normal line distortion is tolerable.

In addition to its general laboratory utility, this instrument is ideally suited for preventing instability and inaccuracy in a.c. computer system nulling operations. Many other applications. 230 V. model also available. Immediate delivery. $1,689 f.o.b. Carlstadt, N. J. Write for details.

Component & Instrument Department

CURTISS-WRIGHT

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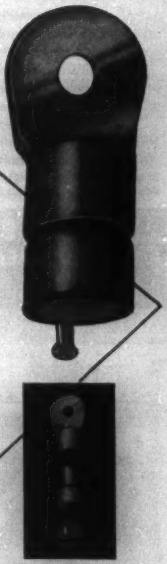
the ... a little longer...

... by A-MP ... the solution for ... aluminum wire termination

No galvanic action . . . oxidation is inhibited . . . full rated conductivity is assured . . . by using A-MP's all aluminum Termalum Terminals. The distinguishing features are the cartridge, containing abrasive inhibitor compound, and the specially-designed symmetrical "C" crimp. Under pressure of the crimp the compound abraids oxide from the wire and prevents it from reforming. The cartridge is closed with a removable plastic plug that is color-coded for wire size identification. The entire terminal is tin-plated by a special process to assure high conductivity and corrosion resistance.



TERMALUM

Trade mark

terminals and connectors

Copalum* Terminals have the same features as Termalum except the body and tongue are made of copper. They can be used for connecting aluminum wire directly to copper busses. Termalum and Copalum Terminals and Connectors exceed all military specifications.

A-MP Termalum and Copalum Terminals are applied with A-MP Dyna-Crimp* or Hand Hydraulic Tools. Dyna-Crimp Tooling is available for bench mounting or with a portable cart. It crimps wire sizes 8 through 4/0. The hand tool crimps sizes 8 through 4.

Write for additional information on these products.

A-MP

AIRCRAFT-MARINE PRODUCTS, INC.

Harrisburg, Pa.

A-MP of Canada, Ltd., Toronto, Canada
A-MP—Holland N.V., 's-Hertogenbosch, Holland
Aircraft-Marine Products (G.B.) Ltd., London, England
Societe A-MP de France, Courbevoise, Seine, France

*Trade mark

FOUR-CHANNEL CARRIER-TELEPHONE TERMINAL FOR RADIO LINKS

This is a miniaturized unit of advanced design which provides four voice channels on a frequency-division basis above a voice-frequency order-wire channel. Each of these five channels is provided with a 4-wire 2-wire termination and a voice-frequency ringing circuit for d-c or 20-cycle signals. Adjustable attenuators are provided in the 4-wire side of all channels, and a built-in test oscillator and meter permit complete line-up, maintenance and trouble-shooting checks to be made. Channel levels are from −9 to 0 dbm and line levels from −30 to 0 dbm. Channel width is 300 to 3500 cycles within 1 db.

This unit is only 5¼" high by 19" wide by 14" deep. It mounts on a standard rack and operates from 115 volts 50-60 cycles a.c.

RADIO ENGINEERING PRODUCTS
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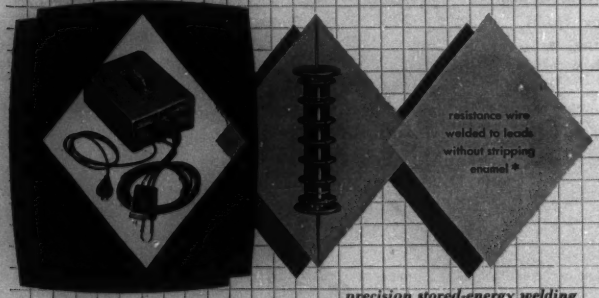
TERMINATE PRECISION RESISTORS WITH SPEED AND RELIABILITY



precision stored-energy welding

WELDMATIC MODEL 1012 TWEEZER TYPE WELDER
welds fine wire to leads or tabs while resistor is on winder. Enamel stripping and flux contamination eliminated, with production time halved. Welded connection is very positive, stable, and rugged.

*Made by Ircal Industries subsidiary, IRC

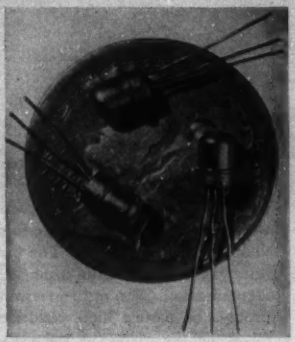
Unitek WELDMATIC

UNITEK CORPORATION
261 Halstead Avenue • Pasadena 8, California
Write for Complete Technical Information on Stored Energy Welding

New Products

(*Continued from page 56A*)

and many other amplifying equipments. Using the new "mighty midgets," Philco's Government and Industrial Division has assembled a miniaturized amplifier about the size of an ordinary pencil eraser. The amplifier, constructed for demonstration purposes only, attains a 70 db gain, or a power gain of 10 million, and utilizes a new type of direct-coupled circuitry developed principally for electronic computers by Philco. In spite of its tiny size, the new subminiature transistor is covered by a metal can which is hermetically sealed by welding to protect the device from moisture and other contaminants. The *M-7* transistor possesses unusual strength by virtue of its tiny size. Excess mass, a weakening factor, has been eliminated. The device can withstand an acceleration rate of 20,000 times the force of gravity without change in characteristics. It also has the transistor's inherent qualities of long life, ruggedness, light weight, and low power consumption. The *M-7* will operate on as little as one ten-thousandth of a watt.



Item 70 on the card.

Fixed or Variable Standard Capacitors. A complete line of fixed or variable standard capacitors, for use as laboratory reference standards in checking bridges and other measuring devices, and for measuring capacitance by the substitution method, is available from the Federal Telephone and Radio Company, a division of International Telephone and Telegraph Corporation. The capacitors can be easily and quickly stacked on several types of bases in a variety of combinations to provide the exact capacitance desired. The variable and fixed units may be mixed when stacking. The capacitors, which may also be used as high quality circuit elements in special applications, cover a range of 6 to 230 $\mu\mu f$ for the variable types and 10 $\mu\mu f$ to 4.0 μf for the fixed types. Each capacitor is mounted in a tubular metal can with a specially designed coaxial screw connector at its base. This connects to a base unit and simultaneously provides a completely shielded electrical connection. Capacitance of the base units is calibrated to the

(*Continued on page 61A*)

(*Continued from page 58A*)

same degree of accuracy as the individual capacitors so that no error is contributed to the total capacitance. The capacitors have a rugged mechanical design, are carefully aged, and are supplied with calibration certificates giving their values and the conditions under which the values were obtained.

Item 73 on the card.

Fluorescent Color Matcher Unit. Color Matcher, a new fluorescent lighting unit that provides the equivalent of natural light entering a north skylight at high noon, the ideal illumination for precision color tasks, has just been announced by the Duro-Test Corporation. Designed to provide light of the best Kelvin temperature (7,500 degrees) for exacting comparison of colors, the unit uses a mixture of six 40-watt fluorescent lamps comprised of four *Super Delux 45* and two standard *Blue* in a Plexiglas and steel fixture. The resulting light covers the full spectrum range and is invaluable for printers; lithographers; commercial artists; paint, wallpaper, and textile producers; cotton classification; fruit and vegetable inspection and grading; furniture; shoe; leather goods; ceramic wares; and lumber industries. Nationwide field tests have verified its uniform and accurate color rendition throughout the entire spectrum, from blue through green, and yellow to red. It also produces strong illumination at working levels, over 75 foot-candles, for optimum visibility.

Item 74 on the card.

Entire Hearing Aid at Ear. The unique Sonotone Corporation *79* hearing aid weighs only 3/4 ounce, is worn entirely at

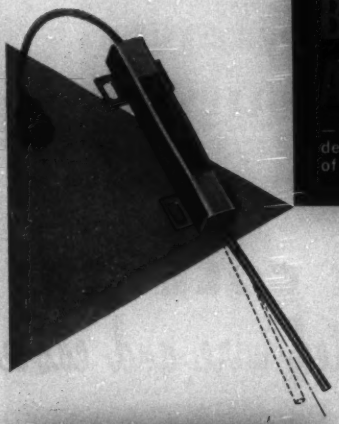
the ear, with nothing on the body and no cords down the neck. It is invisible from most angles on men and completely concealed by women's hair. The entire transmitter, including the dime-size battery,

(*Continued on page 62A*)

SELF ALIGNING SHAFT—
linear motion
potentiometers

BOURNS
ALIGN-O-POT

—highly reliable
despite misalignment
of actuating member



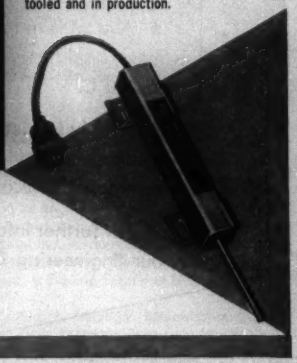
Here is a far-reaching advance in linear motion design. This unit allows for misalignment between the instrument and actuator—eliminating shaft side loads. With no alignment needed, the unit is mounted and installed quickly...is easily designed into a system.

To insure low noise characteristics under extreme vibration, the ALIGN-O-POT wiper assembly is supported throughout its entire travel by parallel guide rods. This provides continuous support directly at the point of contact...multiple contacts are used to further increase the reliability.

The ALIGN-O-POT has a stainless steel case and a flexible cable with plug connector. Standard travels are available from ½" to 6½". Other travels can be provided up to 36". The ALIGN-O-POT is fully tooled and in production.

BOURNS
LINIOMETER

high performance
under environmental
extremes



The LINIOMETER has a bushing-supported shaft and the same highly reliable internal construction as the ALIGN-O-POT—for use where the self-aligning feature is not applicable. Small cross-section and optional mounting configurations are added features of these units. Available in standard travels from ½" to 6½".

the complete line of linear motion potentiometers

Bourns offers a wide selection of standard instruments for any need from ⅛" to 36" travels—all built for maximum reliability and optimum performance. Bourns will work with you on special requirements.

Write for technical literature.

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FOR
LOW-TEMPERATURE
FLEXIBILITY

CHOOSE COLLYER
silicone insulated wire and cable

★ Collyer Silicone Rubber insulation remains flexible even at –65°F, where most conventional insulations are brittle.

★ Available in ratings from 0–5000 V, these insulations serve dependably up to 200°C.

★ Highly resistant to weathering, corona, ultra–violet, oxidation, most common chemicals and condensation.

★ For further information, write or call our Engineering Department.

Collyer

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INSULATED WIRE CO.
245 ROOSEVELT AVE.
PAWTUCKET, R. I.

▲ Circle 76 on the card.

New Products

(*Continued from page 61A*)

four transistors, Sonotone developed microphone, and miniaturized circuitry, fits snugly behind the ear. A curved bridge connects it with the subminiature receiver in the ear. Inconspicuous to operate as well as wear, the new aid has a tiny off-on and power switch which makes it possible for the wearer to control it with the flick of a thumbnail. Similarly, the small battery can be flipped out of the case without removing the aid from the ear, and replaced in a second. The battery can run for as long as 137 hours at a minimum cost. The transmitter case, of polystyrene plastic is resistant to damage, extremes in temperature, and is noncorrosive.

Item 77 on the card.

Variable Speed Drive. The "Selectron," a variable speed drive, has been placed into production by the Electro Dynamic Division of General Dynamics Corporation. It offers a wide speed range compactness, a patented load compensating circuit for close speed regulation, simple installation, stepless control, fast speed response, easy maintenance, as well as many optional features which make it flexible for adaptation to a wide range of equipment throughout all industry. The normal speed range

is 22 to 1, but is available in speed ranges as great as 60 to 1. With tachometer feedback, speed can be controlled to within 1/4 of 1 per cent. Standard optional features include dynamic braking, reversing, and inching control. Power supply is from a-c single phase voltages of 110, 208, 220, 440, or 550 at 50 or 60 cycles. Separate transformers for other voltages are available. Drive motors are of the heavy duty, ball bearing industrial type in standard National Electrical Manufacturers Association frames. Available with motor modifications for special application problems.

Item 78 on the card.

Portable Drafting Machine. *Draftette*, made of anodized aluminum, can cover an area of 11 inches by 17 inches, yet fits snugly into a man's pocket. It is a precision instrument, all scales machine calibrated to 0.0005 of an inch, scientifically engineered to retain its original accuracy. This simple device clamps to drawing board or sketch pad in a jiffy. No special training is required to operate *Draftette*.

Item 79 on the card.

(*Continued on page 76A*)

B-52 jack screw—a typical Boeing design challenge

On Boeing B-52 bombers, the horizontal tail surface has more area than the wing of a standard twin-engine airliner. Yet it can be moved in flight, up or down, to trim the aircraft.

The device that performs this function is a jack screw, which, though it weighs only 255 pounds, can exert a force of approximately 225 *tons!*

Much electrical engineering skill went into designing and developing the controls and thermostats for this jack screw. These thermostats regulate heating elements which guard against potential control system malfunctions at extremely low temperature. Electrical engineers find challenging and highly creative work on Boeing design projects for the B-52, and for the 707 jet tanker-transport, the BOMARC IM-99 pilotless interceptor, and aircraft of the future.

Because of Boeing's steady expansion, there is continuing need for additional engineers. There are more than twice as many engineers with the company now as at the peak of World War II. Because Boeing is an "engineers' company," and promotes from within, these men find unusual opportunities for advancement.

Design engineers at Boeing work with other topnotch engineers in close-knit project teams. They obtain broad experience with outstanding men in many fields, and have full scope for creative expression, professional growth and individual recognition. And they find satisfaction in the high engineering integrity that is a Boeing byword.

In addition to design engineering, there are openings on other Boeing teams in research and production. Engineers and their families like the life in the "just-right" size communities of Seattle and Wichita. They may pursue advanced studies with company assistance in tuition and participate in a most liberal retirement plan. There may be a place for *you* at Boeing-Seattle or Boeing-Wichita.

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If you want further information on the advantages of a career with Boeing, please send coupon to either of the above addresses.

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(Continued from page 62A)

TRADE LITERATURE

VLF RI-FI Equipment Folder. A 4-page illustrated folder on versatile Very Low Frequency radio interference and field intensity measuring equipment is available from Stoddart. The literature features the Stoddart *NM-10A*, which combines laboratory precision with ruggedness and portability for all-weather field operation over a range of 14 kc to 250 kc. Also included is information on a complement of accessories designed to accommodate every conceivable laboratory or field problem in locating and measuring voltage and current values of radio signals or radio interference.

Industrial Image Intensifier. A 3-page bulletin gives engineering data on industrial applications of a Norelco Industrial Image Intensifier. Text deals with fluoroscopic X-ray examination of steel and other metals with high density and absorption characteristics. Typical work is done in daylight using 80 kv (peak) for 1/8 inch of steel and 150 for 7/8 inch of steel with a focal spot size of 0.4 mm, constant potential. Illustrations show details obtained on a defective bearing block and on a faulty welded seam.

Bulletin on Rheostats. An illustrated 4-page bulletin on the new *H-VW-M* universal carbon pile tank rheostats for electroplating is now available. The bulletin describes the advantages of the tank type of rheostat which provides all tank voltages for specified line voltage and maximum amperage conditions. A standard rating chart is provided with instructions on how to select the proper *H-VW-M* carbon pile tank rheostat. Four close-up photographs show sectional and front and rear views of the control panel; a wiring diagram is included as well. Dimensions of the four sizes of *H-VW-M* carbon pile tank rheostats are given, together with the shipping weights. The bulletin contains complete mounting and operating instructions.

Elastomer Booklets. The properties, applications, compounding, vulcanization, and fabrication of *KEL-F* (trade mark) elastomer, a fluorocarbon rubber with outstanding resistance to heat and corrosion, form the subject matter of companion brochures published by The M. W. Kellogg Company. The first of the booklets, 16 pages, is designed for those who might use or specify the elastomer, which is supplied to industry in two grades of gum, differing in processing characteristics and vulcanizate properties. Methods of compounding, vulcanizing, and fabricating the elastomer are described in the 12-page companion-piece, of particular interest to rubber compounders and fabricators.

Bulletin on Inductronic Instruments. A new bulletin just issued by the Weston Electrical Instrument Corporation, Newark 5, N. J., contains a series of technical articles on the Weston line of inductronic instruments, compiled for easy reference. Performance, applications, and ranges of the sensitive Model *1411* inductronic d-c amplifier are discussed in detail. Also reviewed in detail are the Model *1475* multirange inductronic d-c amplifier, as well as the inductronic product resolving system.

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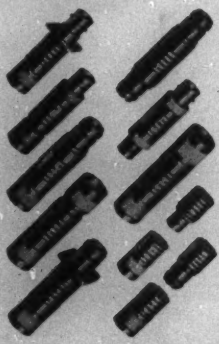

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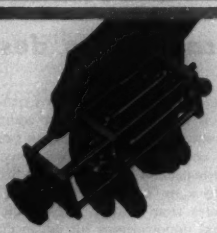

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- **Characteristic Impedance:** 50 ohms.
- **Available Attenuation:** Any value from 1 db to 60 db.
- **Accuracy:** ±0.5 db.
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Insulation Booklet. "How To Insulate Your Home for Electric Heating" is the title of a new publication by the National Mineral Wool Association. Prepared at the request and with the co-operation of the National Electrical Manufacturers Association, the booklet predicts that, within 5 years, more than 100,000 houses will be heated by electricity. The advantages of electric heating are outlined, and various types of electric heating equipment, methods of installing insulation and the proper uses of vapor barriers are described. Single copies of the booklet are available free of charge. Large quantities are available at 5 cents each. Write the National Mineral Wool Association, 2906 Americas Building, New York, N. Y.

Plastics Fabricator Sees Bright Future. A four-color, 20-page booklet tells how Luria-Cournand, Inc., manufacturer of plastic gun-turret enclosures for military aircraft, grew into a diversified plastics research engineering and fabricating firm. The book shows a wide range of Luria-Cournand products and illustrates how they are made. One section describes the company's work in developing new architectural materials from plastics. Another covers the research, development, and testing department. Copies of the brochure may be obtained by writing to Luria-Cournand, Inc., Havre de Grace, Md., on company letterhead.

Catalogue on Aro Tools and Hoists. A new 40-page catalogue, condensed to pocket-size for handy reference, features the complete line of Aro air tools, air hoists, and automation tools manufactured by The Aro Equipment Corporation, Bryan, Ohio. Complete data is also given on Aro air hoists in 1/2 ton and 1-ton capacity, with a choice of cable or pendent control and accessories. This new catalogue number *62* is available free on request to the manufacturer.

New Product Literature Directory. A new 24-page directory of product literature, "This Is A-C from A to Z," has been released by Allis-Chalmers Manufacturing Company. In addition to an alphabetical description of company products and their descriptive literature, the directory has a brief history of Allis-Chalmers as an introduction. Copies of this directory, *B6057*, are available on request from Allis-Chalmers Manufacturing Company, 931 South 70th Street, Milwaukee, Wis.

List of Available Literature. An up-to-date listing, with brief descriptions, of all its available chemical bulletins, has just been issued by Climax Molybdenum Company. Designated *Ch-3*, this 4-page compilation may be obtained from the company on request. The company's available literature

(Continued on page 85A)

(*Continued from page 76A*)

is listed in several categories: chemical data series (13) give comprehensive data on the physical and chemical properties of molybdenum compounds. Agriculture (14) cover research and commercial developments using molybdenum compounds in agriculture and their function in animal nutrition. Analysis (3) review methods of analyzing for molybdenum in the chemical, metallurgical, and agricultural fields. Ceramics (5) deal with applications of molybdenum in refractories and abrasives, as well as enamels. Catalysts (3) cover uses of molybdenum compounds as catalysts and list manufacturers of molybdenum catalysts. Colors (4) review molybdenum inorganic and organic pigments with emphasis on molybdate orange pigments.

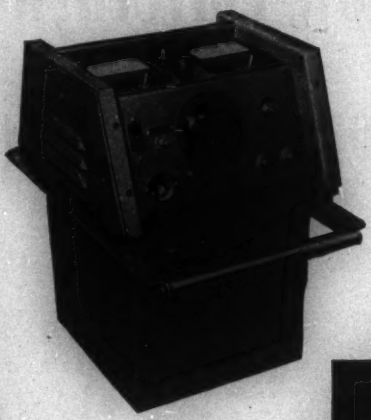
Computing and Simulation Brochure. This 7-page brochure explains the complete services offered for simulation, computing, data reduction, and data processing by the J. B. Rea Company, Inc. Descriptive diagrams clarify the flow of data. From the problem analysis and preparation service, the data is routed to the desired facility, analogue simulation, digital computing and record reading, analogue-to-digital conversion, and digital-to-analogue conversion. Copies of this brochure may be acquired free.

X-Ray Diffraction Use. Literature, describing how metallurgical problems are solved with X-ray diffraction by Kaiser Aluminum and Chemical Corporation, is available gratis. Recently reprinted from a national trade magazine, the article covers actual cases involving the production of foil where the product had tiny pinholes in one instance and improper rolling texture in another. Similarly, the material treats X-ray diffraction applications in connection with corrosion of pipes, welding fluxes, aluminum bronze catalysts, and research.

Automatic Telephone Systems. A new data file on automatic private communication systems has been released by the North Electric Company. It describes in detail a wide variety of automatic telephone systems designed for private use under the North trade name *Privatel*. This is a combination descriptive bulletin and file folder containing a general discussion of private automatic telephone systems, and descriptions of the special features available with *Privatel* exchanges, from conference calling and centralized dictation controls to code calling and watchman's call reporting. Separate data sheets are provided for each of six sizes of switchboards covering requirements all the way from 10 lines on a single link to hundreds of lines engineered for industrial or institutional applications. The file is available without charge to industrial executives, architects, contractors, or communications engineers.

BIDDLE *Instrument News*

Biddle Dielectric Test Set — Model 1-40 KV



—for measuring d-c current at voltages up to 40 kv when applied to the insulation of such equipment as generators, transformers, bushings and cable.

Special hand truck supplied as an accessory for this equipment. This truck permits one man to handle the set safely and without difficulty, on stairways as readily as on the straightaway.

This portable field instrument has been developed in response to the growing use of and demand for higher d-c test voltages.

Carefully considered safety features, excellent output voltage regulation, simple operation, compact design, and facilities for making voltage and current measurements at either polarity have been incorporated in this test set. Years of Biddle engineering experience in insulation testing are reflected in this equipment which has already proven its reliability and performance in field use.

The set has a current rating of 25 milliamperes at short circuit, and current measurements can be made down to 0.5 microamperes which is the first division on the microammeter.

Over-all dimensions are: height 19½ in., width 13½ in., depth 20 in., weight 120 lbs. All high voltage components are oil immersed.

For complete details, description, specifications, and prices, write for **Bulletin 22-EE.**

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1316 Arch St., Phila. 7, Pa.

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Telephone installations show...

How Polyethylene performs in the field

WASHINGTON – Polyethylene-covered cable was first installed in this mountainous region of the Pacific Northwest in 1950. Field experience showed that it was adaptable to any method of hanging and required no special equipment. Installation could be made on existing pole arms without increasing crossarms, pole height, or tree trimming.

The line has withstood extremely heavy snow and ice loading in certain mountain and valley sections. There has been no deterioration despite temperatures 40 deg. below zero. During the summer months, temperatures up to 115 deg. and exposure to sunlight have had no discernible effect.

NEW YORK – Recently, 33,000 feet of cable and 75,000 feet of wire, both insulated with polyethylene, were put into service in upstate New York. Although an unusually large number of thunderstorms were experienced during the year, no lightning damage was reported on these lines. To date, rain conditions have had no effect.

Much of the cable was strung on existing poles, but in the construction of new lines it was found practical to use ⅓ fewer poles. The need for crossarms and tree trimming was also reduced. As a result, maintenance costs in rural areas have stayed low.

For more information circle 99 on reader service card.